THE

# FOUNDRY TRADE JOURNAL

*WITH WHICH IS INCORPORATED*

THE IRON AND STEEL TRADES JOURNAL

VOL. 45. Thursday, October 1, 1931. No. 789.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES' EQUIPMENT AND SUPPLIES ASSOCIATION.

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## Forthcoming Events.

OCTOBER 13.

*Sheffield Metallurgical Association*:—Ordinary meeting at Sheffield. "Salving German Battleships at Scapa Flow," Paper by E. F. Cox.

OCTOBER 15.

*Institution of Welding Engineers*:—Ordinary meeting in London. "Autogenous Welding of Lead and its Alloys, Ancient and Modern," Paper by E. B. Partington.

**Institute of British Foundrymen.**

OCTOBER 3

*Lancashire Branch*:—Ordinary meeting. "Low Total-Carbon Cast Irons and their Service to the Foundryman," Paper by W. West.

OCTOBER 9.

*Sheffield and District Section*:—Joint meeting at Sheffield. "Gases in Metals," Paper by Dr. W. Rosenhain.

OCTOBER 12.

*Institute of Metals (Scottish Local Section)*:—Ordinary meeting. "Some Random Reflections on Industrial Problems and Economies," Paper by L. Short.

## Look to Your Stocks.

Recent political developments have undoubtedly given rise to confidence in the future of our country and its industries, and one may safely look for a return, probably slow, but nevertheless sure, to more prosperous times. One of the first industries to benefit by any such revival is the foundry trade, and, while considering the future, the question of stocks is important. For many months past prices of raw materials have been falling, with the natural result that consumers have been purchasing raw materials in quantities only sufficient to meet immediate needs, whilst the stocks of manufacturers have mounted until they have, in many cases, assumed proportions hitherto unknown.

It is our clear duty to-day to carry on in a normal and rational manner, and one way in which the founder can help is by building up his stocks to their normal level. Such a removal of stocks from the makers would enable them to face the future with this large burden removed from their shoulders, with the result that they could immediately produce at a normal rate, thus giving employment to additional men, instead of remaining "banked down" as they are at present, awaiting the tardy removal of their enormous stocks. So much for the patriotic aspect of the case. Looking at it from a selfish point of view, it would appear that, as far as we can see at present, the foundryman cannot go far wrong by increasing his stocks at once. Prices of raw material are as low as they are likely to be; in fact, an upward tendency is indicated. Any stock laid down now, therefore, is almost certain to increase in cash value. The possession of an adequate stock ensures easy and smooth working, free from the fear of having to slow down owing to non-arrival of raw material and absence of stock. We are being well supplied with slogans to-day as to how to order our lives during the transitional period from what was "darkness" to what we hope will be "light." One of these slogans advises us to "spend, but spend wisely." This can be faithfully carried out by investing in raw materials at the present low prices. Coupled with the glow of satisfaction on making a good investment is the comfortable feeling that, by so doing, a contribution is being made to the future welfare of our country's industries.

## Cast-Iron Roads.

The development of the cast-iron road is one that promises to be of great importance to the foundry industry, and active steps to press the matter are in progress. It forms an ideal mass-production job, likely to absorb considerable tonnage. The Worcester City Council has just authorised the laying of an experimental section, and a member of the Council claimed that it was likely to revolutionise road construction. The cast-iron surface consists of triangular sections which can be built up to any size required, the wearing surface being studded. It is understood that the sections will be laid on a concrete bed six or eight inches deep, and that this would generally be covered with a thin layer of bituminous material. The same material would form a cement between the sections, in which they would be set.

The obvious question arises as to whether the material would be likely to wear under heavy traffic, but this seems unlikely from experiments and trials which have been made, and if a special wearing material is required this would not be beyond the capacity of modern research. Temperature variations seem unlikely to have any material effect, for the thermal expansion is very small.

If the surface wears smooth skidding might be a problem, but it seems likely that the studs will stand up to wear very well. They are staggered so as not to present a continuous groove or rut.

The cost is likely to be greater than the ordinary surface, but the diminished cost of maintenance, repair and replacement is likely to leave a material advantage with the new type. All road users are aware of the vexatious delays and obstruction that occurs as a consequence of the perpetual repair of trunk routes. The cost of this is probably much greater than the cost of repairing the road itself.

Altogether the prospects are promising for the new material, and if any drawbacks showing themselves in service are tackled in the right spirit, with all the aid that metallurgical science can bring to the aid of the founder, the industry should gain a new market of great value. Expenditure on roads in this country since the war has run into hundreds of millions.

XUM

# The British Cast Iron Research Association.

## IX.—OUTSTANDING FEATURES OF THE WORK OF THE ASSOCIATION.

The justification for the work of the Association on purely economic grounds may be judged from the fact that, although its total expenditure since its inception is about £70,000, on two items of work alone it is estimated that application throughout the industry would save it one-fifth to one-quarter of a million sterling per annum. This excludes any consideration of the economic value of other work and of all direct services to members.

The outstanding features are as follow:—

1.—In the field of melting practice, a design of the universally used cupola melting furnace was worked out some years ago calculated to yield more satisfactory melting than the type normally used in Great Britain. This has become known as the "soft-blast" type and several hundreds of these furnaces are working very successfully. More recently a new type (patented) has been evolved which furnishes a most satisfactory cupola melting unit, in respect of melting economy, melting temperature, cleanliness of operation, speed of melting and low cost of repairs. It is estimated that the general adoption of this type throughout the industry would save about £100,000 to £150,000 per annum in fuel, apart from other advantages, and that the whole of the constructional costs involved would be recovered in fuel economy in about twelve months' working. This type (known as the "balanced-blast") is quite recent and at present only about half-a-dozen installations are at work. The quality and temperature of metal obtained are of greater importance to the industry than fuel economy, but it is estimated that in ordinary cases the saving in fuel will be one-quarter to one-half.

2.—In the field of moulding-sand practice, a complete survey has been made of the moulding-sand resources of Great Britain, and a series of tests evolved for determining properties important to the foundry, the whole of which have been applied to about twenty sands representative of types in which over 90 per cent. of British castings are made. For the daily control of moulding sand with a view to most economical use, simple and robust testing apparatus has been designed and is available cheaply to all interested. It is estimated that the application to the industry as a whole of this system of control would save about £100,000 per annum at a negligible initial cost.

3.—The metallurgy of cast iron has been closely studied and a number of contributions have been made to the theory of the subject which are leading to improved understanding of the mechanism of solidification, and the precise problems to be solved in this complex material are daily becoming more clearly defined. Out of this work has arisen a novel series of irons much more resistant to scaling and growth at high temperatures than the best heat-resisting irons hitherto known. These are patented and registered under the trade name "Silal" and they are being used in practice as stoker links, fire bars, furnace castings, etc. It seems probable that an entirely new section of the industry will be built up on this material. More recently a further advance has been made in these heat-resisting alloys which promises to widen still farther the field of application, yielding strong metals even more free from growth and scaling at high-temperatures than the original alloys.

Other advances cover alloy cast irons having, when cast from the furnace, a degree of ductility now only associated with material subjected to a long and expensive annealing process in malleable annealing ovens; irons capable of heat-treatment, to be machinable before and unmachinable (hard-wearing) after treatment; irons which have the hardness of white iron without any of its brittleness, and so on. The "innoculation" process, the inner significance of which the Association has worked out, promises to furnish engineering irons of grey and machinable character, yet higher in strength than have hitherto been obtainable.

4.—Much work has been done on whiteheart malleable cast iron, a material produced in the Midlands since the eighteenth century and having many useful applications. Fundamental to any work on this question is the size and shape of the test-bar used, and its relation to the size of the casting and an investigation on this has just been completed.

5.—Attention has been given to the important question of the criteria of quality of cast metals, that is the size and shape of the test-bar, methods of testing, testing procedure and the correlation of various tests. This work is likely to have a profound influence on the design of castings, a factor as important in competition as cheap production and high quality.

## Correspondence.

*[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]*

### A Pig Cup.

*To the Editor of* The Foundry Trade Journal.

Sir,—To those who have not seen the original of the enclosed photograph, the following details may be of interest to ironfounders and foundrymen generally. The cup is turned down from a piece of pig-iron as poured into the pig bed. The end of the piece from which it was turned is still attached to the base of the cup, and was used as a grip for the clutch of the lathe during the process of turning.

The cup is 6 in. high, the over-all length being 7 in. The outside diameter of the bowl is 2½ in., the inside diameter is 2 7/16 in., leaving the thickness of the bowl 1/32 in. thick, the bowl being 3¼ in. deep.

The cup is free from spot or blemish; is as smooth as glass and shows no visible inclusions of any kind. It is an excellent example of the turner's art in machining to so thin a section. The quality and soundness of the specimen give rise to questions regarding re-melting. The specimen was given to me and formed one of a large group of various designs, each of which were machined from pieces of grey pig-iron. They constitute very fine examples of densities and smoothness.—Yours, etc.,

S. G. Smith.

62, Sylvan Avenue,
Timperley, Cheshire,
September 22, 1931.

[We have not reproduced the photograph, as it adds nothing to the letterpress.—Editor.]

### Machining Allowances for Brass Castings.

*To the Editor of* The Foundry Trade Journal.

Sir,—The amount quoted (3/64 in.) should be just sufficient, but 1/16 in. would be safer. This amount should be put on all over—*i.e.*, ⅛ in. nearly on the diameter. The amount 3/64 in. would be enough for machine-moulded work. Green sand and dry should be treated alike as the various factors affecting the shrinkage offset each other. These remarks all refer to small castings such as the boiler plugs mentioned. For larger or lumpy castings the allowance should be more—depending on the work.—Yours, etc.,

H. C. Dews.

London,
September 29.

## Random Shots.

. . . And still the world goes round. In fact, since the gold standard was "bumped off," a spirit of jubilation has been lurking around, and while this may be merely a natural reaction to the novel phenomenon of somebody having done something at long last, nevertheless it has been attended by an improvement, temporary at least, in the trade of the country. One hears of orders being booked; and even though they be secured by competitors, it is cheering news, indicating that those wee timorous beasties of buyers are once more emerging from their burrows.

* * *

I'm not too sure that it is confidence the buyers want at this moment. A few rumours of imminent advances in prices might have a more stimulating effect upon them, and actually are having so. When prices do begin to rise, pig-iron will be among the first of raw materials to register an increase. And when the pig-iron salesman is kind enough to forewarn the consumer, the consumer ought in return to forearm himself by buying just a ton or two more than he needs for his next melt!

* * *

It has been whispered in "Marksman's" ear that there is a foundry consultant up North who is advising the smaller country jobbing foundries to purchase imported pig-iron. If the iron of our own manufacture were as poor in quality as some of that which is imported, or if trade conditions were such that our stocks were negligible, then that consultant's advice to his clients could be passed without serious comment. But at a time when we are being urged, as much by common-sense as by our politicians, to buy British for our own economic preservation, and when the Brobdinagdian stocks of iron in this country are squeezing the laughter out of life for our iron producers, that consultant is deserving of the harshest of criticism.

* * *

Of course, as ever, there is another side to the picture—in this case illustrated by the following extract from a prominent ironfounder's letter of a fortnight ago to an equally prominent firm of foundry suppliers: "As we have previously advised you, we are quite agreeable to pay a slightly higher price for a British-made material, but so far you have not displayed very much interest in supplying this material."

* * *

Little Tales of the Depression.

*Miss Amelia's Amelioration.*

The managing director of the Narrow-Shave Razor Blade Company was distraught. Sales of the firm's patent blade had been dwindling consistently for two years. The old selling tricks had been tried without avail. A free razor was presented to each purchaser of six blades; a tube of shaving cream was given with every two blades; for twelve coupons, equivalent to a dozen blades, one could receive a strop and a shaving mirror. Everything had been done to facilitate shaving with Narrow-Shave blades, yet still the sales diminished. Then Miss Amelia, whose chief duty was to prepare afternoon tea for the managers and assistant managers, broke into the emergency board meeting and addressed the directors in ringing tones: "Why not establish throughout the country a service of Narrow-Shave shaving saloons?" she cried. "All the customer has to do is pay for the blade—we will do the rest!" The directors applauded and adopted her suggestion. There are now several thousands of Narrow-Shave service saloons in the country, and the sales of Narrow-Shave blades have soared to ten figures. Miss Amelia still makes afternoon tea—but not for managers and their assistants.

Marksman.

# Twenty Years' Advance in Electric Arc-Furnaces for the Production of Iron and Steel.*

By W. E. Moore.

During the past 20 years the electric-arc melting and refining furnace has made remarkable progress. In the year 1910 there were ten electric steel furnaces in operation in the United States, which produced 52,141 gross tons of electric steel during the year. In 1930 there were approximately 650 electric furnaces in operation on steel and iron in the United States having an average annual output of more than 1,000,000 tons, in the ratio of ingots one-third, and steel and iron castings two-thirds. Approximately one-third of all the steel for castings is now electrically melted.

### The Heroult and Snyder Furnaces.

The Heroult electric furnace had been established in commercial production before 1910 in sizes ranging from one ton to fifteen tons holding capacity. These furnaces were, as a rule, used at that time for producing tool steels requiring sulphur and phosphorus limits usually below 0.025 per cent., and were therefore customarily basic, lined with magnesite.

On account of his education and long experience as a chemist and metallurgist, Dr. Heroult very early had a thorough conception of the metallurgical reactions and of the various kinds of slags and processes which could be used advantageously in electric-arc furnace practice. The art and process of electric steel making was generously and generally explained by Dr. Heroult without attempting to patent the various processes and materials, and in this way he gave the electric-arc steel-making art unselfishly to the use of the public, though he broadly patented his electric furnaces.

The shell or sidewall linings of the Heroult furnace were usually made of magnesite brick up to the slag line or to 4 to 6 in. above it. The remainder of the shell lining above the magnesite brick was made of silica brick. The roof refractories were, in standard practice, made of silica brick, although firebrick had been many times tried experimentally, as were also tamped or rammed roofs, but the silica-brick roof was soon found to be the best, in that it maintained rigidity, even at elevated temperatures up to 1,650 deg. C. or more, whereas the firebrick showed considerable settlement at these high temperatures.

Originally, the Heroult furnace roofs were built up with standard shapes, which were hand trimmed to form electrode eyes through the roof, and other standard shapes were fitted by experienced bricklayers to line the sidewalls of the shell. The roofs were originally built up in, and held by, steel rings made, generally, of two angles bent to a circle and riveted to a wrapper plate.

While the Heroult furnace was from the beginning basic lined and operated with a basic slag for reducing sulphur and phosphorus in the manufacture of tool steels, quite early in the industrial development of the electric furnace commercial operations were put into effect by Heroult with acid linings, consisting of gannister bottom sintered in while the entire shell was lined with silica sidewalls. The greater reactivity of the silica on the steel resulted in markedly hastening the finishing or quieting part of the furnace cycle, and as the materials for acid-bottom making and slag making were only a fraction of the cost of the basic lining and slag materials such furnaces became popular, particularly for casting work.

As the electric furnace was improved in efficiency and rapidity and the central stations and industrial plant sources of power supply were augmented to sufficient magnitude and reasonable power cost to permit the operation of electric furnaces on commercial tonnage as well as quality production, their number and production made rapid increase.

It had originally been assumed that the electric furnace operation, while producing superior steel, was adapted only, on account of the relatively high operating costs, to the manufacture of the finest alloy and tool steels.

In 1910, however, F. T. Snyder came into the field with a competing electric furnace known as the Snyder single-phase electric furnace. Snyder based his original furnace designs on the experiments which had been performed in 1878 by Siemens in England on a single-phase, single vertical adjustable electrode furnace of the acid-lined type. Siemens, in his acid-lined furnace, had been entirely successful in melting and refining wrought iron into a high-quality tool steel, but at that time the quantity of power available was so restricted and the cost was so excessive that the operations initiated by Siemens were not commercially followed through by steel manufacturers, although he had outlined the details of the process quite clearly and explained the procedure scientifically and with unmistakable logic.

By 1910, however, at the time when Snyder took up commercial electric-furnace steel production, the art of power generation was well advanced, and steam turbines of large sizes and high thermal efficiencies were in commercial use. The power costs were greatly reduced by this improvement over the old reciprocating-engine prime-movers.

Heroult, at this time, had obtained a re-issue patent, claiming broadly the use of a plurality of electrodes with current operating in series down through the electrodes—metal bath—slag, and out the other electrode or electrodes. Snyder, following the Siemens exposition, used a single electrode with current flowing through the electrode, through the slag, through the metal to a water-cooled electrode built into the furnace bottom, preferably acid-lined. The Snyder system had the great advantage of simplicity in that only one vertical electrode was involved, and that, being in the geometrical centre of the cylindrical furnace crucible, showed very little tendency for the arc to blow or lap the sidewalls. This permitted very simple furnace construction and the lowest possible consumption of electrodes in lbs. per ton melted.

The Heroult furnace had always been operated with quite low voltages, ranging usually from 80 to 120 volts across the electrodes. The earlier Heroult furnaces were as a rule operated each from its own individual generator with the field control conveniently arranged near the furnace switchboard, so that the voltage and/or load might be varied within generator range at will by the furnace operator at any part of the furnace cycle.

Some of these earlier furnaces, such as the 15-ton Heroult furnaces at Chicago and at Worcester, were operated from a large central power system where it was not practicable to vary the generator voltage, and were accordingly arranged with variable voltage transformers. The earlier Heroult furnaces, all being of comparatively large size, heavy current, low voltage, had generally a sufficiency of inherent reactance in the secondary circuits, so that the arcs were not wild and no separate reactors were used. The low voltage of these Heroult furnaces required comparatively large currents, heavy conductors and large electrodes, which were then always made of carbon. With their short arcs and large electrodes the Heroult furnaces were not adapted to making low-carbon steel; in fact it was said of these early furnaces that they were not successfully operated on steels of less than 0.25 per cent. carbon and preferably 0.50 per cent. or higher carbon.

Snyder, on the other hand, initiated his furnace with graphite electrodes of small size and designed on the theory of a comparatively high voltage arc ranging from 110 to 220 volts, depending on furnace size, which made the current to be handled correspondingly light and arcs rather long. To overcome the destructive effect of a long arc on the roof, Snyder made his shells relatively high, and kept the doors at a low level and made them as nearly gas tight as possible, so that the upper portion of the furnace crucible was, in practice, filled with and shaded by a cloud of smoke or fumes which greatly protected the roof against deterioration from his long arc.

Snyder's furnace established its first commercial activity in making steel for castings, being for that time high-powered and more rapid than the Heroult, and being usually fitted with a plain acid lining, it was quite simple for foundrymen to operate. Since the Snyder secondary circuit was of comparatively high voltage and low amperage, its reactance was correspondingly small, and Snyder early found it essential to stabilise the arcs with additional or outside reactance, which practice was early standardised. But the Heroult furnaces having low voltage, heavy-current power connection continued to operate without separate reactors until a much later period, but during the war the necessity for great production compelled furnace users to adopt higher voltages, which made the installation of outside reactance essential to stabilise the power input.

The Snyder furnace had a simple and ingenious design of roof refractories, consisting of quadrangular pyramidal silica blocks, which were used as a single section for building up the spheroidal-form roof, which was sprung in the roof ring of circular section. The Snyder furnaces were also provided with ingenious door mechanism, which decreased circulation of oxidising gases and minimised heat losses through the doors. During the war, Snyder became impressed with the necessity for saving time on furnaces, as electric furnaces were becoming larger in size and the time consumed for charging became an objectionable and expensive feature in their operation (some of the larger furnaces requiring one hour or over to charge). It was then that Snyder devised a simple mechanism pivot for pulling back the roof so that, by means of the same mechanism that tilted the furnace forward for tapping, the roof with the electrode connected might be tilted backward, permitting the furnace crucible to be charged through the top with a drop-bottom bucket.

### Regulators.

The Snyder furnaces were generally fitted with sufficient reactance to stabilise the arc by running at a power factor of 45 to 75 per cent. It was comparatively easy to adjust the electrode by hand crank-wheel, since there was only one electrode to keep in adjustment, which, together with its arm and column rigging, was well designed for light-weight easy operation. The Snyder furnace is no longer manufactured.

The Heroult furnaces, on the other hand, from the early days had the electrode gear fitted with automatic electrode control. Thury, of Geneva, had developed and put into commercial operation an ingenious and complete automatic gear for regulating the current on his constant current generators, and the speed and power on his constant-current circuit power system motors. This was early adapted to electric-furnace use, and was continued as a standard part of Heroult furnace equipment up to and

(*Continued on page* 204.)

* A Paper read before the American Electrochemical Society.

# The Zürich Congress of the N.I.A.T.M.

The Congress of the New International Association for Testing Materials was held from September 8 to 12 at the Federal Technical High School at Zürich. The Association continues the activities of the body of the same name which existed before the war and which held some ten conferences at three-yearly intervals, the last one being at New York in 1913. At a conference held in 1928 in Amsterdam, a general feeling manifested itself towards the re-establishment of the Association, and this has been done with emphatic success. The new body has some 2,000 members and at Zürich the number of registrations was about 600, some thirty countries sending official delegates. The new body does not work quite on the same lines as its predecessor, for it has not the same system of permanent committees, nor does it in any way concern itself with international specifications. It exists to interchange knowledge and ideas, not to come to final conclusions.

Of the four sections into which the work of the conference was divided, Group A, the metals, was easily that of most interest to the metallurgist, the other groups dealing with other inorganic and organic materials and with general questions. The Chairman of group A was Dr. W. Rosenhain, F.R.S., who earned a spontaneous and remarkable tribute for the ability and skill with which he summarised in any two languages (English, French or German) the contributions made in the remaining one during the discussions. At the final session Dr. Rosenhain was elected President of the Association for the next conference, to be held in London in 1934.

### Testing Grey-Iron Castings.

The plan of operations had been to invite "international experts of acknowledged reputation" to contribute Papers on specified topics which were acknowledged to be of vital interest at the present time, and it is of great interest to learn that cast-iron testing was one of the subjects. Indeed, the discussion on cast iron was first on the programme, being opened by a Paper by Mr. J. G. Pearce, director of the British Cast Iron Research Association. Subsequent Papers were given by Prof. Piwowarsky, of Aachen, by Prof. A. Portevin, of Paris, by Prof. F. Pisek, of Brno (Czecho-Slovakia) and by Dr. E. Dübi, of Switzerland, all on the same question of tests for cast iron. The divergence between the British and French views was pronounced, and a very lively discussion took place. Prof. Portevin, in his Paper, pressed for the Congress to decide on methods of testing. Dr. Rosenhain, as chairman, declined to accept this proposal, in view of the constitution of the Association, but ultimately agreed to draw up an expression of view of the Congress as a whole as the result of the discussion. In order to do this as well as possible he invited three gentlemen to prepare a memorandum on the matter, embodying points of agreement, phrased as judicially as possible and free from controversy. The Congress agreed, and Dr. Dübi (Switzerland), Prof. Portevin (France) and Mr. Pearce (Great Britain) were elected to prepare the necessary memoranda. Dr. Rosenhain's summary was not issued before the close of the meeting. Prof. Portevin's Paper naturally pressed the claims of the shear test on the piece taken from the casting, and asked the Congress to decide on tests from the casting and not from a test bar, and also to decide on the nature of the tests and size of the pieces.

### Shear Test Relegated to Research Sphere.

Dr. Dübi presented an elaborate and valuable Paper, coming to the conclusion that "the use of the separately-cast test-piece should not be abandoned. It ensures entirely satisfactory comparison between various kinds of cast iron, and, furthermore, enables conclusions to be drawn regarding the strength properties of the main casting, of which it is a specimen." This Paper gives the official conclusions of the Swiss Association for Testing Materials.

Prof. Pisek reported a Paper embodying the official conclusions of the Czecho-Slovak Standards Association, concluding, "The types of test finally adopted for the standard specifications for castings are the tensile test . . . and the transverse test. . . ." Prof. Piwowarsky's Paper did not deal directly with the controversial issue, but in Germany (as also in U.S.A.) the transverse and tensile tests are in regular use. During the discussion at Zürich, Dutch opinion was expressed in favour of the British proposals, as was Belgian opinion during the London Conference (Institute of British Foundrymen) of 1930.

Thus an overwhelming body of industrial opinion mobilised in favour of the separate test-bar for transverse and tensile tests for testing castings, and much of this is in favour of the test-bar varying in section with the casting to be tested, as originally adopted in Great Britain (B.E.S.A. Specification 321—1928).

It only remains to add that, although the testing of the casting by means of a trepanned piece taken from the casting has not found favour as an acceptance or routine test, or a test for use in specifications, there is general agreement that small test-pieces taken from the casting are likely to be of great value as a means of exploring the properties of the casting itself; that is for research and investigational purposes. In this connection the small tensile-testing machine, recently developed in this country, is likely to prove of value.

### Milan Endorses Zürich.

The Conference at Zürich was immediately followed by the International Foundry Congress at Milan, at which a meeting was held of the International Commission for Methods of Testing Cast Iron, Prof. Portevin being in the chair. This meeting approved of a scheme for the interchange of information and knowledge of work done between the various countries, and to pursue the study of the subject, but no proposals with respect to the shear test were discussed, and for practical purposes the shear test on a trepanned bar, as a routine or acceptance test, is no longer a controversial issue. Prof. Portevin, on a motion moved by the British delegates, was warmly thanked for his interest in the Commission and re-elected President.

About 30 representatives from Great Britain registered for the Congress. Other important questions discussed in the Metals Section were the strength of metals at high temperatures, fatigue, the notched-bar test and the progress of metallography. In Group C a series of Papers was read on the determination of grain size of loose materials (such as sands), while in Group D there were discussions on the calibration and accuracy of testing machines, and on relationships between elasticity, plasticity, toughness and brittleness. While the British delegation was numerically small, it was very active and fully upheld the prestige of this country in this important field, the choice of London as the place of meeting for the next conference indicating in a measure the sense of the value of the research done in this country.

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**Pulleys** can be lagged with sheet rubber by cleaning and coating the pulley face with shellac or fish glue, and fixing the rubber with bolts, countersinking them so that the heads are below the surface of the rubber.

**Hints for Commercial Visitors to Bulgaria.**—A Memorandum bearing this title, prepared by the British Consul at Sofia, has been published by the Department of Overseas Trade (35, Old Queen Street, Westminster, S.W.1). (Reference No. C.3,642.)

## Catalogues Received.

**Refractories.**—General Refractories, Limited, of Genefrax House, Wicker Arches, Sheffield, have struck a new note in their publicity by the issue of a 44-page book containing a well-blended mixture of serious advertising, philosophy, politics and humour. There is one thing certain, however, it will attract more individual attention than the stereotyped article. Whilst this booklet is very suitable for home buyers, it would not be suitable for creating an export business, and we suggest the preparation of a "soul-less production" for this purpose. It should be noted that the company does not confine its activities entirely to refractory materials, or even slag-making materials, but core compounds, molasses, blast sand, crazy-paving stones, tar-macadam, marl for cricket pitches, and rockery stones are also marketed. We are fairly familiar with this firm's manufactures, but to use an Americanism, Xylanthrax is a new one on us, and we suspect its inclusion to have every letter of the alphabet represented in their products.

We note that this is No. 1 and dated August, and, presumably, the forerunner of further efforts. Candidly, we are already looking forward to a second edition.

**Hire-Purchase Financing.** — The Bankers Commercial Security, Limited, Regent Arcade House, 252, Regent Street, London, W.1, in an 8-page pamphlet, set out the system they have launched for enabling industries to buy plant on the hire-purchase system. Foundry equipment is specifically mentioned.

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## Twenty Years' Advance in Electric-Arc Furnaces for the Production of Iron and Steel.

(*Continued from page* 203.)

including a large part of the war activities. At about that time, John Seede, of the General Electric Company, brought out a magnetic contactor, current relay controlled, automatic servo-motor-operated electrode gear that at once became popular and was widely used.

In Europe the automatic electrode regulator development was along the lines of a hydraulic electrode control, using direct acting servo-motor cylinders to lift or lower the electrodes by means of water pressure controlled by current relays to regulate the flow to and from the hydraulic-cylinder servo-motors connected directly to the electrode hoist gear.

At a later date, about 1920, the Westinghouse Electric & Manufacturing Company brought out their automatic electric regulator for handling the furnace electrodes. This was operated on a balance system in which current relays were balanced against voltage relays and also fitted with anti-hunting devices. The balanced-voltage-current system was a material advance in preventing the electrodes "dipping" and wasting away while carboning up the bath. At the same time, the anti-hunting device generally permitted electrode hoist speeds two to three times as fast without "hunting," which tended to improve the power factor of the furnaces as well as their metallurgical characteristics.

Both the early Girod and Stassano furnaces installed in the United States were equipped with automatic hydraulic electrode regulators. These furnaces were, however, of such design that they were operated at extremely high maintenance, were slow and inefficient, and never became popular with the steelmakers. When their popularity died, the hydraulic regulator died with them, perhaps an unnatural death, for the hydraulic regulator has many fundamental advantages, though it might be said that steelmakers generally seem to prefer electric rather than hydraulic apparatus.

(*To be concluded.*)

# Mechanical Properties of Malleable Iron on Various Sized Test-Bars.*

By A. L. Norbury, D.Sc. (British Cast Iron Research Association, Birmingham).

(*Concluded from page* 182.)

[*Errata.*—In the first part of this article (Foundry Trade Journal, September 17), owing to an author's error, the photomicrographs at 35 dias. magnification of the 0.25-in. and 0.564-in. dia. bars have been interchanged in all cases; that is to say, the photomicrograph labelled Fig. A should have been labelled Fig. B, and *vice-versa*. Similarly with Figs. D and E, G and H, J and K, and M and N.]

## RESULTS OF MECHANICAL TESTS.

### Transverse Strength of Blackheart Malleable.

*Figs. 2 and 3.*—Five sets of blackheart malleable test-bars, cast and annealed under the same conditions, were tested. The variations in chemical composition are very small (see Table I), and there is no systematic difference between the mechanical properties of the different sets.

In Fig. 2, on the round bars, the transverse strength rises very markedly with increase in diameter of test-bar. The size of the ferrite grains did not vary appreciably with size of bar. The increase in strength may be partly due to the increase in distance apart of the graphite nodules (see Figs. A and B), and also partly due to the weak oxidised skin having a smaller effect in the case of the larger bars, but is chiefly due to the different distribution of tensile and compressive stresses in the transverse test as the size of test-bar varies. In Fig. 3, on the oblong bars, the strength increases in a similar manner, for the same reasons.

It is interesting to compare the strengths in Fig. 2 with those in Fig. 3. In the case of a complex material like malleable iron, and more particularly whiteheart malleable iron, whose structure varies from edge to centre, it is not to be expected that the mechanical properties of round and oblong test-bars would be the same; the comparison, however, is interesting, and the simplest method seems to be to compare the results on a ¼-in. round bar with those on a ¼-in. thick bar, those on a ½-in. round bar with those on a ½-in. thick bar, and so on. Compared in this way, the round and oblong bars in Figs. 2 and 3 have similar strengths on the smallest-sized bars, but as the size of the test-bar increases, the round bars give increasingly higher results than the oblong bars. On the ¾-in. sizes the difference is as much as about 14 per cent. A similar difference in transverse strength between round and square bars was found in the case of grey cast iron.[4]

### Tensile Strength of Blackheart Malleable.

In Fig. 4, on the round bars, the tensile strength decreases slightly with increase in size of test-bar (in Fig. 2, under the same conditions, the transverse strength increased). The only difference in microstructure (see Figs. A and B) that could account for the above decrease are the increase in size of the graphite nodules and the decreased effect of the decarbonised material near the outside. In Fig. 5 the oblong bars give low and somewhat erratic tensile strengths on the thinnest bars. Microscopic examination showed that these were due to oxidised shrinkage cracks which increased in size as the bars decreased in thickness. They were probably due to shrinkage in the white iron during solidification, and better results could doubtless be obtained by running the bars differently. It is presumably the low total-carbon content (2.40 per cent.) of the blackheart that made it liable to this form of shrinkage. If it were not for these defects the tensile strengths in Figs. 4 and 5 would probably be similar for equal sizes of test-bar.

### Yield Point of Blackheart Malleable.

The yield points have not been plotted. On the round bars (Table II) they decrease from 19 to 16 tons per sq. in. as the size of test-bar increases. On the oblong bars (Table III) they do not vary systematically with size of test-bar, but are between 16 and 18 tons per sq. in., that is to say, similar to the round bars.

### Bend Properties of Blackheart Malleable.

In Fig. 6 on the round bars, the results are somewhat erratic on the smallest sized bars. As the size of test-bar increases the bend decreases, just as it would in the case of a pure metal, owing to the different distribution of tensile and compressive stresses as the size of test-bar varies. In Fig. 7 the bend varies in a similar manner. Comparing Figs. 6 and 7, on the average the round bars give somewhat better bends than the oblong bars.

### Elongation of Blackheart Malleable.

In Fig. 8 the elongation decreases with size of test-bar. This is largely due to the gauge length having (owing to a misunderstanding) been kept at 1 in. for bars up to 0.358 in. dia. and kept at 2 in. for the larger sized bars instead of having been varied according to the cross section, as shown in Fig. 1. It may also be that the size and distance apart of the graphite nodules (see Figs. A and B) affect the elongation.

In Fig. 9 the elongation is very low on the smallest sized bars owing to oxidised shrinkage cracks referred to above when discussing Fig. 5.

Table I.—*Analyses (Before Annealing) and Time and Temperature of Annealing of Malleable Cast Iron Test-Bars.*

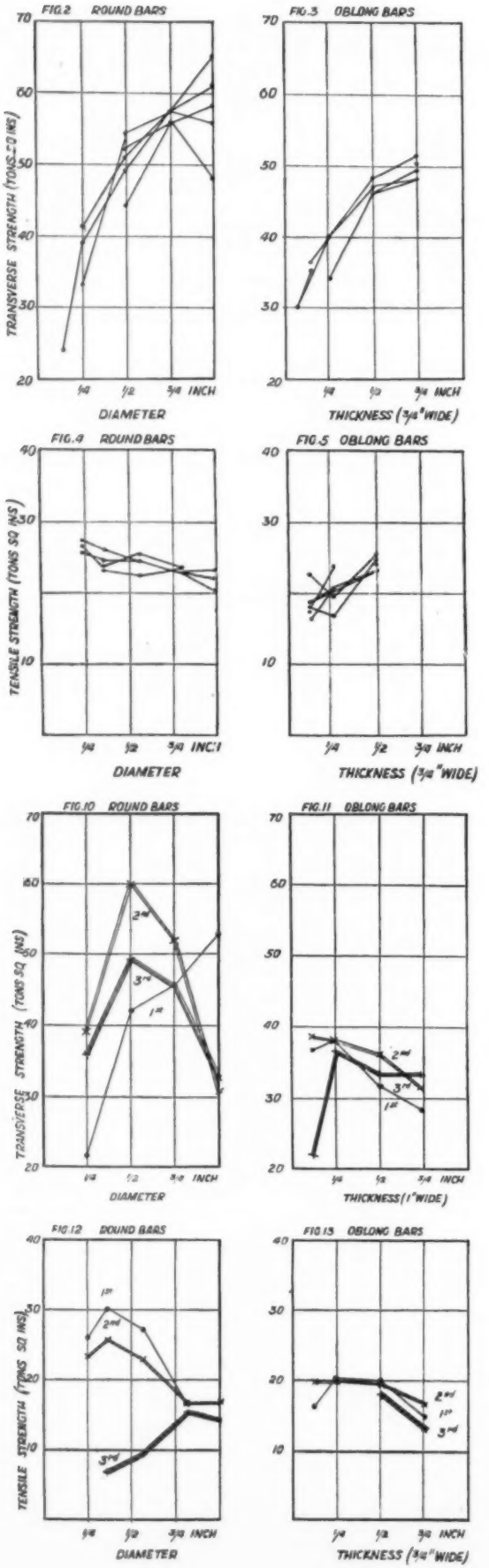
| | Cast No. | T.C. Per cent. | Si. Per cent. | Mn. Per cent. | S. Per cent. | P. Per cent. | Time and Temp. of Annealing. |
|---|---|---|---|---|---|---|---|
| Blackheart | 1 | 2.40 | 1.32 | 0.31 | — | 0.146 | 120 hrs. at 870 deg. –880 deg. C. |
| | 2 | 2.35 | 1.36 | 0.28 | — | 0.146 | do. |
| | 3 | 2.40 | 1.41 | 0.24 | — | 0.114 | do. |
| | 4 | 2.50 | 1.25 | 0.24 | — | 0.158 | do. |
| | 5 | 2.43 | 1.27 | 0.21 | — | 0.154 | do. |
| Whiteheart after 1, 2 and 3 anneals | 6 | 3.84 | 0.49 | 0.10 | 0.230 | 0.079 | 120 hrs. at 900 deg. –1,000 deg. C. |
| | 7 | 3.84 | 0.49 | 0.10 | 0.230 | 0.079 | 2 anneals as above. |
| | 8 | 3.84 | 0.49 | 0.10 | 0.230 | 0.079 | 3 anneals as above. |
| Whiteheart with 0.08 and 0.57 per cent. Mn. | 9 | 3.64 | 0.49 | 0.08 | 0.216 | 0.064 | 120 hrs. at 900 deg. –1,000 deg. C. |
| | 10 | 3.64 | 0.49 | 0.08 | 0.216 | 0.064 | do. |
| | 11 | 3.64 | 0.49 | 0.57 | 0.216 | 0.064 | do. |

Table II.—*Transverse, Bend and Tensile Tests on Round Bars of Malleable Cast Iron.*

| Cast number. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Test-bar dia. In. | Blackheart. Normal anneal. | | | | | Whiteheart. No. of Anneals. 1 | 2 | 3 | Whiteheart. 0.08 per cent. Mn. | | 0.57 per cent. Mn. |
| Transverse strength (Tons per sq. in.) | 1.0 | 58 | 48 | 61 | 56 | 65 | 53 | 31 | 33 | 44 | 49 | 60 |
| | 0.75 | 56 | 56 | 57 | 57 | — | 46 | 52 | 46 | 49 | 35 | 58 |
| | 0.5 | 52 | 44 | 54 | 51 | 49 | 42 | 60 | 50 | 51 | 46 | 57 |
| | 0.25 | — | — | 33 | 41 | 39 | 22 | 39 | 36 | 29 | 23 | 30 |
| Bend (in degrees) | 1.0 | 43 | 22 | 53 | 30 | 45 | 2 | 3 | 5 | 6 | 4 | 12 |
| | 0.75 | 135 | 35 | 86 | 52 | — | 7 | 9 | 8 | 9 | 8 | 16 |
| | 0.5 | >180 | 35 | 151 | 44 | 80 | 12 | 34 | 35 | 29 | 18 | 24 |
| | 0.25 | — | 10 | 31 | >180 | 62 | 154 | 175 | 180 | 16 | >180 | >180 |
| Tensile strength (Tons per sq. in.) | 0.977 | — | 22 | 20 | 18 | 24 | 17 | 17 | 14 | 15 | 13 | 14 |
| | 0.798 | 24 | 23 | 23 | 23 | 23 | 17 | 17 | 16 | 21 | 21 | 26 |
| | 0.564 | 23 | 25 | 25 | 25 | — | 27 | 23 | 9 | 20 | 20 | 27 |
| | 0.358 | 23 | 26 | 24 | 24 | — | 30 | 25 | 7 | 22 | 17 | 24 |
| | 0.253 | — | 27 | 26 | 27 | — | 26 | 23 | — | 21 | 19 | 20 |
| | 9.126 | — | — | — | — | — | — | — | — | 22 | 21 | 20 |
| Elongation Per cent. on 2 in. | 0.977 | — | 9 | 6 | 3 | 10 | 0 | 0 | 0 | 1 | 1 | 1 |
| | 0.798 | 15 | 9 | 15 | 12 | 10 | 0 | 1 | 0 | 2 | 2 | 3 |
| | 0.564 | 9 | 16 | 12 | 20 | — | 0 | 1 | 3 | 2 | 2 | 3 |
| Elongation Per cent. on 1 in. | 0.358 | 19 | 20 | 17 | 7 | — | 4 | 5 | 10 | 10 | 3 | 5 |
| | 0.253 | — | 27 | 18 | 18 | — | 7 | 12 | — | 15 | 13 | 12 |
| | 0.126 | — | — | — | — | — | — | — | — | — | — | 10 |
| Yield point .. (Tons per sq. in.) | 0.977 | — | 16 | 16 | 17 | 17 | — | — | — | 15 | 13 | 14 |
| | 0.798 | 16 | 17 | 17 | 17 | 17 | — | — | — | 18 | 14 | 19 |
| | 0.564 | 17 | 18 | 18 | 18 | — | — | — | — | 18 | 19 | 18 |
| | 0.358 | 17 | 19 | 18 | 17 | — | — | — | — | 12 | 12 | 18 |
| | 0.253 | — | 19 | 19 | 16 | — | — | — | — | 14 | 12 | 13 |
| | 0.126 | — | — | — | — | — | — | — | — | 14 | — | — |

4 Norbury, "Transverse Tests on Round and Square Bars of Grey Cast Iron," "B.C.I.R.A. Bulletin," No. 21. Page 7.

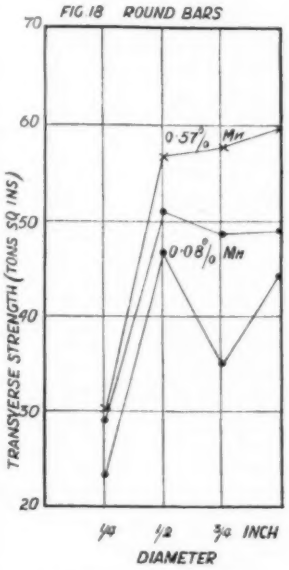
## Mechanical Properties of Malleable Iron Test-Bars.

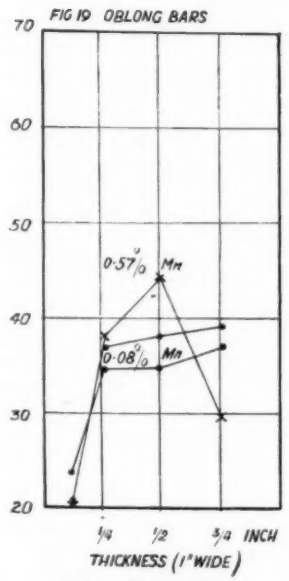


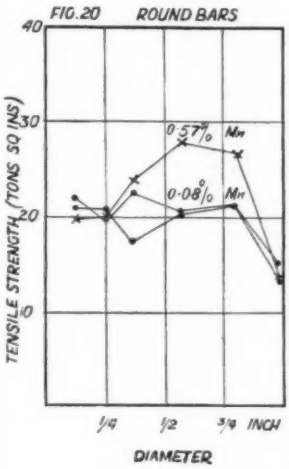

### Transverse Strength of Whiteheart Malleable after One, Two and Three Anneals.

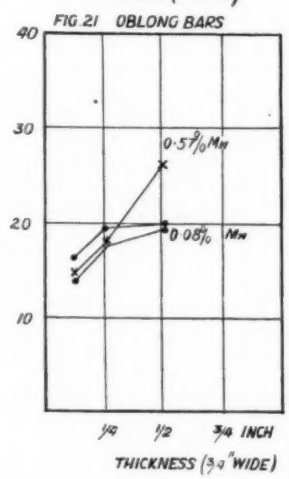
In Fig. 10 the transverse strength increases on the ¼-in. bars from the first to the second anneal owing to the refinement of the pearlite-ferrite structure (see Figs. D and G) and falls slightly from the second to the third anneal owing to the increase in size of the ferrite outer ring (see Figs. G and J). On the 0.564-in. bars the strength increases from the first to the second anneal owing to the replacement of decomposed white iron and pearlite in the interior by pearlite and secondary cementite (see Figs. E, F and H, I). It falls from the second to the third anneal,

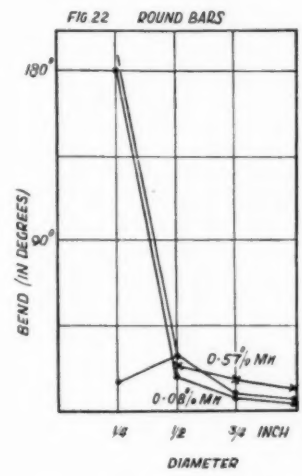
## Mechanical Properties of Malleable Iron Test-Bars.

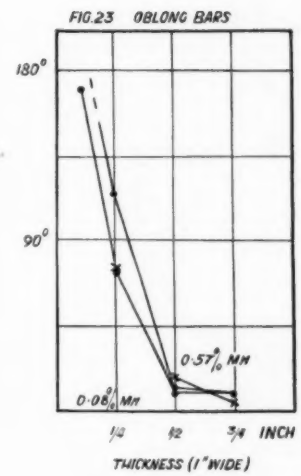


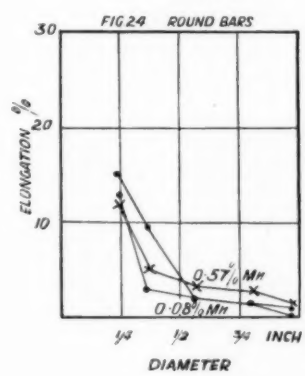



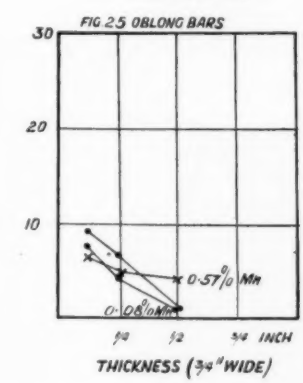




probably chiefly owing to the increase in depth of the ferrite in the outer ring (see Figs. H, I and K, L). The strengths on the 1-in. dia. bars are erratic, since they are influenced by the presence in variable amounts of spots of grey iron in the bars in the as-cast condition. In Fig. 11 the strength, generally speaking, increases from the first to the second anneal and falls from the second to the third anneal for reasons similar to the above. The differences are, however, much less marked. The oblong bars in Fig. 11, on the medium sizes, give much lower results than the round bars.

### Tensile Strength of Whiteheart Malleable after One, Two and Three Anneals.

In Fig. 12 the tensile strength falls from first to second and from second to third anneal. This appears to be due to the presence of increasing amounts of ferrite round the outer portions of the bars which lower the strength more than the substitution of decomposed white iron by pearlite in the centre increases it (see Figs. D to L). The low strengths of the two smallest bars after the third anneal are due to oxidation penetrating down flaws. In Fig. 13 there is much less difference between the strengths after the three anneals (as in Fig. 11) and the strengths are again lower on the medium sized oblong bars than on the round bars.

### Bend Properties of Whiteheart Malleable after One, Two and Three Anneals.

In Figs. 14 and 15 the bend increases from first to second and from second to third anneal, since all the changes of microstructure (shown in Figs. D to L) which result in lowering of the combined carbon content tend to increase the ductility. The round bars again give better results than the oblong bars.

### Elongation of Whiteheart Malleable after One, Two and Three Anneals.

The remarks made regarding Figs. 14 and 15 apply similarly to Figs. 16 and 17. On the smallest sized oblong bars there are indications of the elongation being low due to oxidised shrinkage cracks as was the case in Fig. 9.

Table III.—*Transverse, Bend and Tensile Tests on Oblong Bars of Malleable Cast Iron.*

| Cast number. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Test-bar thickness. In. | Blackheart. Normal anneal. | | | | | Whiteheart. Number of anneals. | | | Whiteheart. 0.08 per cent. Mn. | | 0.57 per cent. Mn. |
| | | | | | | | 1 | 2 | 3 | | | |
| Transverse strength (tons per sq. in.). | 0.75 | 49 | 48 | 48 | 51 | 50 | 28 | 31 | 33 | 39 | 37 | 30 |
| | 0.5 | 46 | 46 | 47 | 48 | — | 32 | 36 | 33 | 35 | 38 | 44 |
| | 0.25 | 34 | 34 | 40 | 40 | — | 38 | 38 | 37 | 34 | 37 | 38 |
| | 0.125 | — | 35 | — | 36 | — | 37 | 38 | 22 | 23 | 21 | 20 |
| | 0.06 | — | 18 | 30 | 30 | — | — | — | — | — | — | — |
| Bend (in degrees). | 0.75 | 43 | 30 | 35 | 55 | 32 | 5 | 4 | 8 | 6 | 7 | 4 |
| | 0.5 | 65 | 60 | 132 | 68 | — | 8 | 11 | 10 | 10 | 12 | 18 |
| | 0.25 | — | 36 | 155 | 136 | — | 20 | 55 | 60 | 73 | 115 | 75 |
| | 0.125 | 50 | >180 | — | 160 | — | 27 | 180 | 180 | >180 | 168 | >180 |
| | 0.06 | — | 45 | 85 | >180 | — | — | — | — | 100 | — | 170 |
| Tensile strength (tons per sq. in.). | 0.75 | 24 | 20 | 23 | 22 | 22 | 15 | 17 | 13 | — | — | — |
| | 0.5 | 23 | 25 | 24 | 25 | — | 20 | 19 | 18 | 20 | 20 | 26 |
| | 0.25 | — | 17 | 20 | 19 | 24 | 20 | 20 | — | 18 | 19 | 18 |
| | 0.125 | 18 | 18 | 16 | 23 | 17 | 16 | 20 | — | 16 | 14 | 15 |
| Elongation (per cent. on 2 in.). | 0.75 | 14 | 8 | 13 | 8 | 8 | 0 | 0 | 0 | — | — | — |
| | 0.5 | 15 | 12 | 14 | 15 | — | 1 | 1 | 3 | 1 | 1 | 4 |
| | 0.25 | — | 3 | 7 | 6 | 11 | 5 | 5 | — | 4 | 6 | 5 |
| | 0.125 | 2 | 0 | 2 | 5 | 3 | 2 | 6 | — | 9 | 8 | 6 |
| Yield point (tons per sq. in.). | 0.75 | — | — | — | — | — | — | — | — | — | — | — |
| | 0.5 | 16 | 17 | 17 | 18 | — | — | — | — | 18 | 17 | 19 |
| | 0.25 | — | 16 | 17 | 16 | 17 | — | — | — | 11 | 11 | 11 |
| | 0.125 | 16 | 18 | 16 | 17 | 16 | — | — | — | 9 | 9 | 9 |

**Transverse Strength of Whiteheart Malleable containing 0.08 and 0.57 per cent. Manganese.**

In Fig. 18, on the 0.25-in. bars the addition of manganese has not appreciably affected the strength. The microstructures are shown in Figs. D and M, and it appears that the coarse pearlite-ferrite structure shown in Fig. D is similar in strength to the finer structure shown in Fig. M, in spite of the latter's much lower pearlite content. On the ½-in. bars the strength has increased due to the replacement of the decomposed white iron in the interior (see Figs. E and F) by the chiefly pearlitic structure (see Figs. N and O). The effect of the increased manganese content is similar in Fig. 19, and, as before, the round bars give better results than the oblong bars on the larger sizes.

**Tensile Strength of Whiteheart Malleable containing 0.08 and 0.57 per cent. Manganese.**

In Figs. 20 and 21 there is again little difference in the strength of the smallest-sized bars, but again the increased manganese content has considerably increased the strength of the medium-sized bars for reasons indicated above. The tensile strengths on the round and oblong bars are similar on the ½-in. sizes, but for the smaller sizes the oblong bars give lower results, probably owing to shrinkage cracks, as was the case in Fig. 5.

**Bend Properties of Whiteheart Malleable containing 0.08 and 0.57 per cent. Manganese.**

In Figs. 22 and 23 the manganese addition has increased the bend on all bars, except the smallest—for which the results are erratic—this is due to the action of manganese in lowering the combined carbon content (compare Figs. D, E, F with M, N, O). The round bars again give better results than the oblong bars.

**Elongation of Whiteheart Malleable containing 0.08 and 0.57 per cent. Manganese.**

The increased manganese content has improved the elongation on the largest-sized bars in the same way that it improved the bend in Figs. 22 and 23. The oblong bars, again, give lower elongations than the round bars on the smallest sizes, due to shrinkage cracks.

**Yield Point of Whiteheart Malleable containing 0.08 and 0.57 per cent. Manganese.**

Generally speaking, the yield point increases, as shown in Tables II and III, from 12 or 14 tons per sq. in. to 19 tons per sq. in. with increase in size of test-bar as the combined carbon content increases, and then falls on the largest-sized bars due to the presence of spots of grey iron in the bars in the as-cast condition. The results do not bring out any effect of increasing the manganese content on the yield point.

**Relation of Microstructure to Mechanical Properties.**

The relation of microstructure to mechanical properties is relatively simple in the case of blackheart malleable, but is very complicated in the case of whiteheart malleable, where several different micro-constituents are present in variable amounts from edge to centre of the material. It is possible, however, from the photomicrographs and mechanical tests given in what has preceded, and from knowledge of the effects of the same micro-constituents in the case of steels, to summarise the relation of microstructure to mechanical properties for malleable irons. The following micro-constituents may be present and will be considered in turn.

(a) *Temper-Carbon Nodules.*—The nodules may be present in a round, compact form (see Figs. F, I, L) if the composition is such that the iron does not readily graphitise on heating, or in a more diffuse form (see Figs. C and O) if the reverse is the case, owing, in the cases shown in Figs. C and O, to higher silicon and manganese contents than the former. The latter type of temper-carbon dissolves in the matrix on annealing more rapidly than the former.

(b) *Spots of Primary Grey Iron.*—Spots of grey iron are liable to be present in the white iron in the as-cast condition in the case of the thicker sections, particularly if the silicon or total carbon or manganese are on the high side. The spots of primary grey iron are of themselves sources of weakness, and are liable to become oxidised and still further weaken the iron.

(c) *Ferrite.*—Ferrite is the constituent forming the matrix of ordinary blackheart (Figs. A to C) and thin section whiteheart, and is present in the outer regions of thicker section whiteheart. It is also present round the graphite nodules in whiteheart with increased manganese content (Figs. N and O) and would be present in greater quantity in such material if slower rates of cooling were adopted. The properties of ferrite are influenced by the crystal size and by the amount of silicon in solid solution. Each 1 per cent. silicon in solid solution increases the tensile strength by about 5 tons per sq. in., but lowers the elongation. Manganese is never present in solid solution in ferrite in sufficient quantity in malleable iron to affect the strength or ductility appreciably. Ferrite is more ductile but has less strength than pearlite.

(d) *Ferrite-Pearlite.*—Ferrite-pearlite, if present in whiteheart malleable, occurs (in progressively increasing amounts of pearlite and decreasing amounts of ferrite) inside the ferrite band. In some cases it is in a relatively coarse form (see Fig. D), in other cases in a relatively fine form (see Figs. G, J, etc.). It appears that the coarse form arises from white iron in the centre diffusing towards the decarbonised edge, while the fine form results from graphite nodules dissolving to give carbon in solid solution. The fine form has greater strength than the coarse.

(e) *Pearlite.*—Pearlite, if present in whiteheart malleable, occurs inside the pearlite-ferrite band (see Figs. H, K, L). In the case of annealed steels, increasing the combined carbon increases the tensile strength by about 2 tons per sq. in. for each 0.1 per cent. combined carbon, but decreases the elongation to about 5 per cent. on 2 in. with 0.9 per cent. combined carbon. Pearlite sometimes occurs in blackheart malleable in the material free from graphite nodules near the outside. It is purposely obtained as above in "picture frame" blackheart by lowering the silicon content and increasing the manganese content. Lowering the silicon content reduces the tendency for graphite nodules to form near the outside before the carbide is removed by decarbonisation, and increasing the manganese content makes the combined carbon sufficiently stable not to graphitise if graphite nodules are not present.

(f) *Secondary Cementite.*—Secondary cementite, if present, is associated with the pearlite (see Fig. I) inside the pearlite band. It occurs in whiteheart malleable irons low in manganese (*e.g.*, 0.1 per cent. or less). It decreases the ductility of pearlite, but probably has little effect on its strength.

(g) *Undecomposed White Iron.*—Undecomposed white iron, if present, occurs in the centre of whiteheart malleable (see Fig. F) inside the pearlite-secondary cementite band. Its presence lowers both ductility and strength.

(h) *Sulphides.*—Yellow iron sulphide is present as small crystals in low-manganese whiteheart and does not greatly lower the mechanical properties. If, however, owing to annealing at too high a temperature, it migrates and crystallises at the crystal boundaries, it lowers the ductility and strength very considerably. If the manganese content is raised sufficiently, blue-grey manganese sulphide is formed which is liable to segregate in the solidifying white iron. With intermediate manganese contents mixtures of the above sulphides are present.

(i) *Oxides.*—Oxides and silicates are present in small quantities—chiefly at the crystal boundaries—at the extreme edge of malleable iron and may also penetrate inwards to a considerable distance locally down shrinkage cracks or spots of grey iron. They cause locally almost complete loss of strength and ductility.

**Standard Test-Bars of Malleable Iron.**

The results recorded in the present Paper have an obvious bearing on the problem of deciding on the best size and shape of standard test-bar for malleable iron. At the present time most countries have adopted round tensile bars about ½ in. dia., and call for certain tensile strengths and elongations for various grades of blackheart and of whiteheart. The strengths, etc., vary somewhat from one country to another. Bend tests on oblong and round bars and yield points, hardness and magnetic tests, and chemical composition limits, etc., are also included in certain specifications.

It is evident from the results in the present Paper, firstly, that higher and more reliable results are obtained by using round test-bars as against oblong test-bars, and secondly, that it is necessary to relate the cross-section of the test-bar to the cross-section of the casting if the properties of the one are to be any indication of the properties of the other. This is particularly the case with whiteheart, where definitely misleading results would be obtained if this were not done. Generally speaking, blackheart is chiefly used for castings having wall-thicknesses of the order of ¼ in. and over, and for such the 0.564-in. test-bar and possibly a larger one—say 0.977 in.—would be suitable. Whiteheart, on the other hand, is chiefly used for castings of lesser wall-thickness than the above, and since ductility is usually the chief quality required, the castings are often tested by hammering out flat until cracks occur, or by bending and twisting. If a standard round tensile bar were considered desirable for such castings, one of smaller diameter than the above—say 0.253 in.—would appear to be most suitable.[5] Although this test-bar is small, reasonably accurate tensile strengths, yield points and elongations can be obtained on it (see Table I). It would thus be possible to standardise three sizes of round test-bar, 0.253 in., 0.564 in. and 0.977 in. dia. The two smallest bars would be used for whiteheart and the two largest for blackheart. If two sizes of test-bar instead of one were used for each batch of material the results obtained would afford very useful information regarding the properties of the material and would in many cases suggest the cause of any variation from normal practice.

The experimental work recorded in the present Paper was carried out by members of the staff of the Association. Thanks are also due to members of the Association who cast and annealed the test-bars, and to these members and to the Council for permission to publish the results.

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**High-Temperature Alloys in the Nickel-Cobalt-Iron System.**—Messrs. C. R. Austin and G. P. Halliwell, in Technical Publication No. 430, issued by the American Institute of Mining and Metallurgical Engineers, deal with the mechanical properties at elevated temperatures of nickel-cobalt-iron base alloys containing a few per cent. titanium. A limited number of alloys also contained additions of a fifth element. The properties of these alloys were examined by use of the conventional high-temperature tensile test, by a new high-temperature bend test and by Vickers hardness tests on the alloys aged at various temperatures for a maximum of 3,000 hrs. It is suggested that marked ageing characteristics of the alloys was due to the presence of titanium. Data have been provided illustrating that in many of the alloys about 80 per cent. of maximum age hardening is completed after 72 hrs. at 650 deg. C. Prolonged ageing at this temperature does not usually lead to a decrease in the hardness of the fully-aged alloy. The tensile tests reveal unusually high values for the ultimate strength and proportional limit at 600 deg. C.

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5 This size of test-bar has also been advocated by Stotz, "Die Giesserei," Vol. 17, March 14, 1930. Page 251, and by Rémy, "Bulletin de L'Association Technique de Fonderie," October, 1930, Page 323.

XUM

# Unsoundness in Aluminium Sand Castings.

## PART I.—PINHOLES: THEIR CAUSES AND PREVENTION.

By Prof. D. Hanson, D.Sc., and I. G. Slater, M.Sc.

(*Concluded from page* 196.)

### Large-Scale Experimental Melts.

Further experiments were made involving the gas-treatment of aluminium-alloy melts using larger quantities of metal under works conditions.* A large stock of "3L11" alloy of identical composition was prepared from virgin aluminium ingot and a 50: 50 per cent. temper alloy by melting in an oil-fired iron pot furnace and casting 7-lb. ingots into chill iron moulds. The temper alloy was melted in an oil-fired crucible furnace from electrolytic copper and "Red End" virgin aluminium ingot, the latter quality of ingot being used also for the final melt; 60 lbs. of this stock "3L11" alloy were taken for each test, an oil-fired furnace and a new Morgan plumbago crucible being used. Starting from cold, about 45 min. heating was required to melt the charge and bring the temperature up to 700 deg. C. Chlorine and nitrogen were obtained from cylinders, the nitrogen being dried by bubbling through concentrated sulphuric acid contained in two large Dreschel wash-bottles and a single large Woulf's bottle, another similar Woulf's bottle being used for chlorine. The gases were introduced into the melt via an iron pipe of ½ in. external diameter, on the end of which was affixed, by means of two locknuts, an inverted 3-in. plumbago crucible drilled near to the open end with eight ¼-in. dia. holes. The flow of gas was adjusted to about 15 to 20 bubbles per sec.—a fairly rapid rate—and bubbled into the bottom of the 12-in. depth of metal contained in the crucible. During treatment the furnace burners were turned off.

The following test-pieces were cast from each treated melt:—

(1) *Standard taper block* in (*a*) skin-dried green sand (S); (*b*) stove-dried sand (D); (2) *Luvax casting* in (*a*) skin-dried green sand (S) (a disc 5 in. dia × ½ in. with central boss 2 in. dia. × 2 in.) and (*b*) stove-dried sand (D), and (3) two tensile test-bars in stove-dried sand moulds.

The inclusion of stove-dried moulds in these tests is explained later. The following treatments were carried out:—

No. 1.—*No Treatment.* 60-lbs. "3L11" ingot melted down, temperature raised to 720 deg. C., and the casting poured immediately.

No. 2.—*Treatment with Nitrogen.* Dry nitrogen gas bubbled into melt at 730 deg. C. for 20 min., castings poured immediately at 720 deg. C.

No. 3.—*Treatment with Chlorine at* 730 *deg. C.* Dry chlorine gas bubbled into melt at 730 deg. C. for 10 min., when the experiment had to be terminated owing to the gas pipe burning through. A quantity of white dross formed, and the castings poured immediately at 720 deg. C.

No. 4.—*Treatment with Mixture of Chlorine and Nitrogen.* A mixture in equal proportions of chlorine and nitrogen bubbled into melt at 730 deg. C. for 10 min. A quantity of white fume was evolved from the melt during treatment, which proceeded with a fairly vigorous reaction, the gas bubbling freely through the metal. The temperature rose to 760 deg. C. during the treatment, and was allowed to cool to 720 deg. C. before casting.

No. 5.—*Treatment with Chlorine followed by Nitrogen.* Dry chlorine gas bubbled into melt for 10 min. at 730 deg. C., followed by nitrogen for 5 min. Castings poured at 720 deg. C.

No. 6.—*Chlorine Treatment at* 660 *deg. C.* Dry chlorine gas bubbled into melt at 660 deg. C. for 20 min., at the end of which the temperature had risen to 670 deg. C., when the castings were poured immediately at this temperature.

No. 7.—*Effect of Reheating No.* 6. After casting No. 6 test castings, the crucible containing the remaining 50 lbs. of metal was returned to the furnace and reheated for 10 min. to bring the temperature up to 720 deg. C., when a further set of castings was immediately poured.

No. 8.—*Chlorine and Nitrogen Treatment.* This was carried out as for No. 4 treatment, but the gassing was continued for 20 min. with the crucible cooling to 720 deg. C.

No. 9.—*Effect of Further Treatment with Sodium.* After pouring No. 8 casting, the remainder of the metal in the crucible was treated with 0.1 per cent. metallic sodium, the operation being carried out as in the modifying process for the aluminium-silicon alloys. The object of this treatment was to effect grain-size reduction and to clear chlorine gas, if any, retained in the melt.

Much trouble was experienced with the gas lead-in pipe, which became blocked up with chlorides in a few minutes, often burning right through. For experiments of longer duration, two or three new pipes were required for one treatment. No inconvenience was caused by the escape of chlorine into the atmosphere from the melt being treated, that which was not absorbed by the metal being effectively taken up by the flues. Evolution of gas on solidification of the castings was observed only with the taper blocks from the untreated metal.

The density was determined of each of the castings, and the results are given in Table V. The tensile test-bars were then machined to 0.564 in. dia. and broken. Sections were made of the taper blocks in the usual manner, and the Luvax casting was sectioned through the centre after preparing the bottom face. Sections of the taper blocks Nos. M.I.D. and M.8.S. are illustrated in Figs. 20 and 21.

It should be observed that, during treatment, the heating burners were turned off. No contamination of the melt by furnace fuels or products of combustion occurred subsequent to the commencement of the treatment—except in the case of No. 7, as indicated above.

The results of these treatments agree well with the laboratory experiments using the 3-lb. melts. Density determinations made on the castings (taper block, Luvax castings and tensile test-

Fig. 17.—No. 88, "2L5." Held at 950 deg. C. for 1 hr. Cast 700 deg. C.

Fig. 18. — No. 101, "3L11." 0.1 per cent. Selenium added.

Fig. 19. — No. 86, "3L11." 1.0 per cent. Tellurium added.

Fig. 20. — M. I. D., "3L11." Not treated.

Fig. 21. — M. 8. S., "3L11." Chlorine and Nitrogen, 20 min.

Figs. 17 to 21 reduced approximately 50 per cent. in reproduction.


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* Through the courtesy of Messrs. Wm. Mills, Limited, Birmingham, these experiments were carried out in their foundry.

piece) show excellent agreement with the visual appearance of the prepared sections.

Nitrogen is found to effect moderate improvement. Chlorine at 700 deg. C. gives but little improvement. Treatment at 660 deg. C. with this gas proves much more satisfactory. (The low densities recorded for the No. 6 castings are due to the presence of casting unsoundness and misruns caused by the very low pouring temperature.) On heating up this melt to a casting temperature of 720 deg. C., some gas is absorbed from the furnace atmosphere, as is shown by the appearance of further pinholes in the castings, which, however, are still fairly good. A

Table V.—*Summary of Experiments made under Works Conditions—60-lb. Experimental Melts.*

| Treatment No. | Specimen No. | Density. Taper block. | Density. Lavax casting. | Density. Tensile test-piece. | Tensile tests. Yield point. Tons/sq. in. | Tensile tests. Ultimate strength. Tons/sq. in. | Tensile tests. Elongation on 2 in. |
|---|---|---|---|---|---|---|---|
| 1 | 1.S. | 2.801 | 2.828 | 2.831 | 6.00 | 8.24 | 2.5 |
| | 1.D. | 2.800 | 2.827 | 2.830 | 5.80 | 8.32 | 2.5 |
| 2 | 2.S. | 2.824 | 2.835 | 2.842 | 4.72 | 7.64 | 2.0 |
| | 2.D. | 2.813 | 2.834 | 2.836 | 5.64 | 8.48 | 2.5 |
| 3 | 3.S. | 2.805 | 2.836 | 2.841 | 5.76 | 8.36 | 2.5 |
| | 3.D. | 2.806 | 2.831 | 2.836 | 6.00 | 8.52 | 2.0 |
| 4 | 4.S. | 2.821 | 2.844 | 2.846 | 6.00 | 8.04 | 1.5 |
| | 4.D. | 2.818 | 2.852 | 2.849 | 5.76 | 8.52 | 2.5 |
| 5 | 5.S. | 2.794 | 2.825 | 2.837 | 6.20 | 7.92 | 2.5 |
| | 5.D. | 2.815 | 2.828 | 2.840 | 4.4 | 8.0 | 2.5 |
| 6 | 6.S. | 2.800* | 2.828* | 2.859* | 5.32* | 5.80* | 1.0* |
| | 6.D. | 2.819* | 2.830* | 2.839* | 5.32* | 6.28* | 1.0* |
| 7 | 7.S. | 2.828 | 2.852 | 2.854 | 5.28 | 8.92 | 2.0 |
| | 7.D. | 2.822 | 2.834 | 2.854 | 5.88 | 8.10 | 2.0 |
| 8 | 8.S. | 2.838 | 2.859 | 2.864 | 6.8 | 10.24 | 3.0 |
| | 8.D. | 2.839 | 2.852 | 2.866 | 5.48 | 9.72 | 2.0 |
| 9 | 9.S. | 2.823 | 2.852 | 2.840 | 5.72 | 8.84 | 2.0 |
| | 9.D. | 2.826 | 2.834 | 2.844 | 5.24 | 7.92 | 3.0 |

* These castings were unsound due to the very low casting temperature, and are not representative (*see* note in text). They were practically free from "pinholes."

treatment with chlorine followed by nitrogen is relatively ineffective. Castings practically free from pinholes are obtained from the melts treated with a mixture of chlorine and nitrogen. The addition of 0.1 per cent. sodium to the gas-free melt results in a deterioration. Grain size is reduced, but pinholes and cavities of larger dimensions have appeared.

Tensile tests made on the nine treated melts show that none of the treatments has a deleterious effect on the tensile properties of the alloys. With the pinhole-free metal (No. 8) a slightly higher elongation and an increase in tensile strength of 20 per cent. are observed.

### Treatment of 200 to 300-lb. Melts.

The melts used in this series of experiments were taken from those used in production, and the procedure adopted, other than the experimental treatment, was that of the normal foundry routine. Three iron-pot tilting furnaces of similar design heated with town's gas were used. The charges were made up from the requisite quantities of virgin ingot, 50:50 per cent. (copper-aluminium) temper alloy, and spelter. Both the "2L5" and the 3L11" alloy were melted in 200 to 300-lb. charges, treated, and the treated metal was used for castings and production, as well as for test-blocks. The test-blocks were the standard ones used regularly in the foundry for the observation of pinholes, and were cylindrical blocks 3 in. dia. by 3 in. high, cast with an open top in a stove-dried sand mould. These test-blocks were prepared for visual examination of pinholes by turning off ½ in. of metal from the base of each, the cross-section so obtained then being polished and etched. This method is alternative to the vertical sectioning of the block, and it has been found to yield satisfactory comparative results.

The gas-treatment apparatus was specially made up for works practice. It was built in one compact unit with cylinders of chlorine and nitrogen, delivering gas to a final mixing bottle and thence to a length of rubber hose. The nitrogen was dried by passage through two large calcium-chloride towers arranged in series. The mixed gases were introduced into the melt by means of a large iron pipe lined externally with asbestos string coated in lime wash, and internally with alundum tubes of 1.25 in. internal diameter. In spite of these precautions, the life of the lead-in tube was never more than 2 hrs., due to the combined attack of chlorine gas and molten aluminium. A "stainless" nickel-chromium steel tube of 1 in. internal diameter was also tried, but failed after about 20 minutes' service.

Treatments were made in each experiment with a mixture in approximately equal proportions of nitrogen and chlorine. Gas treatment of the melt was commenced as soon as the charge had melted down (at about 630 deg. C.), and continued during heating to the furnace pouring temperature of 760 deg. C.—with certain exceptions, as described later. The usual vigorous reaction occurred during treatment, and fume was evolved in some quantity towards the end of the treatment as the temperature approached 760 deg. C. Dross in larger quantity than usual was formed, the nature of which was similar to that reported upon in the laboratory experiments.

The test-blocks were taken from the melt at the finishing temperature of 760 deg. C. and allowed to cool to 700 deg. C. in the hand ladle before casting. In experiments 8, 9 and 14, treatment was commenced with the heating gas turned off and blocks cast prior to continuing the treatment as the temperature rose to 760 deg. C. Details of the melts treated are given in Table VI.

The density-determination figures must be accepted with some degree of caution, since they will vary from charge to charge due to unavoidable slight variations in weighing out the original charge and hence in composition. The extremes found in blocks cast from various untreated melts of the same alloy were in the case of "2L5" alloy, 2.917 to 2.924, and in the case of the "3L11" alloy, 2.810 to 2.828.

Table VI.—*Effect of Cl and N under Works Conditions.*

| Identification. | Treatment. | Density. | Appearance. |
|---|---|---|---|
| "2L5"–1 not treated .. | Not treated—average of several blocks taken | 2.920 | Moderate. |
| "3L11"–1 not treated .. | " " " " | 2.820 | Moderately bad. |
| "2L5"–2 .. .. | Chlorine and nitrogen for 30 min., 630 deg.–760 deg. C. | 2.952 | Fair to better. |
| "2L5"–3 .. .. | Chlorine and nitrogen for 15 min., 630 deg.–760 deg. C. | 2.931 | " " |
| "2L5"–4 .. .. | " " " " | 2.944 | " " |
| "2L5"–7 .. .. | Chlorine and nitrogen for 30 min., 630 deg.–760 deg. C. | 2.893 | " " |
| "2L5"–14a .. .. | Before treatment on melting at 640 deg. C.. . | 2.939 | Moderate. |
| "2L5"–14b .. .. | Chlorine and nitrogen at 640 deg.–680 deg. C. heating gas off 10 min. | 2.977 | Nearly sound. |
| "2L5"–14c .. .. | Chlorine and nitrogen at 680 deg.–705 deg. C. heating gas on 10 min. | 2.959 | " " |
| "2L5"–14d .. .. | Chlorine and nitrogen at 705 deg.–760 deg. C. heating gas on 10 min. | 2.931 | Less nearly sound. |
| "3L11"–5 .. .. | Chlorine and nitrogen for 20 min., 630 deg.–760 deg. C. | 2.800 | Moderately bad. |
| "3L11"–6 .. .. | " " " " | — | " " |
| "3L11"–8a .. .. | Chlorine and nitrogen at 630 deg.–660 deg. C. heating gas off 10 min. | 2.844 | Moderate. |
| "3L11"–8b .. .. | Chlorine and nitrogen at 660 deg.–720 deg. C. heating gas on 10 min. | 2.827 | " |
| "3L11"–8c .. .. | Chlorine and nitrogen at 720 deg.–760 deg. C. heating gas on 10 min. | 2.828 | Moderately bad. |
| "3L11"–9a .. .. | Chlorine and nitrogen at 630 deg.–770 deg. C. heating gas off 15 min. | 2.844 | Fair. |
| "3L11"–9b .. .. | Chlorine and nitrogen at 700 deg.–760 deg. C. heating gas on 10 min. | 2.833 | Moderately bad. |

Treatment of the 200 to 300-lb. melts has proved to be not so successful as with the 60-lb. and the 3-lb. experimental melts. The "2L5" alloy appears to be more amenable to treatment than the "3L11" alloy. In those treatments where the temperature has not risen above about 700 deg. C., *i.e.*, 14B and C, 8A and B, 9A, the treatment has resulted in the production of a casting nearly free from pinholes with the "2L5" alloy, but has not been quite so effective with the "3L11" alloy. The improvement obtainable where the temperature has been taken to 760 deg. C. is relatively small. A finishing temperature of 750 to 760 deg. C. is necessary under production conditions, since due allowance must be made for heat loss in the transference of the metal to the mould which is cast at 690 to 720 deg. C.

It would appear that with gas-fired iron pot

Table VII.

| Ingot No. | Alloy. | Treatment. | Density. | Appearance. |
|---|---|---|---|---|
| 17 | M. "3L11" .. | None .. .. .. .. .. .. | 2.810 | Moderate. |
| 71 | M. "2L5" .. | " .. .. .. .. .. | 2.900 | " |
| 72 | M. "Y" .. | " .. .. .. .. .. | 2.714 | " |
| 73 | M. Si .. | " .. .. .. .. .. | 2.604 | " |
| 213 | M. "3L11" .. | 4 c.c. titanium tetrachloride per lb.—Rosenhain method | 2.821 | Several small pinholes. |
| 214 | M. "2L5" .. | " " " " | 2.915 | A few small pinholes. |
| 217 | M. "Y" .. | " " " " | 2.740 | Practically sound. |
| 216 | M. Si .. | " " " " | 2.635 | A few large pinholes. |
| 56 | M. "3L11" .. | 4 c.c. titanium tetrachloride per lb. soaked on asbestos wool | 2.797 | Several small pinholes. |
| 65 | M. "3L11" .. | 12 c.c. titanium tetrachloride per lb. soaked on asbestos wool | 2.778 | " " |
| 78 | M. "2L5" .. | 4 c.c. titanium tetrachloride per lb. soaked on asbestos wool | 2.907 | A few small pinholes. |
| 80 | M. "Y" .. | " " " " | 2.746 | Practically sound. |
| 81 | M. Si .. .. | " " " " | 2.605 | A few large pinholes. |

Sections of ingots Nos. 56 and 80 are illustrated in Figs. 10 and 11.

furnaces, the rate of deterioration of the metal due to the absorption of furnace gases may become, at the higher temperatures, more rapid than the beneficial action of the nitrogen and chlorine treatment.

### Titanium Tetrachloride.

The use of titanium tetrachloride for the removal of dissolved gas and grain refinement in aluminium-alloy melts has been investigated by Rosenhain, Grogan and Schofield.[6] Similar experiments have been made on the four alloys using both the method due to Rosenhain for the introduction of the liquid titanium tetrachloride into the melt, and a method in which a ball of dry asbestos wool is soaked with a few c.c. of the liquid and immediately plunged under the surface of the melt by means of an inverted crucible mounted on an iron rod. The large and objectionable volume of fume which is evolved from the melt during treatment, unless the rate of addition of the liquid is very slow, presents a great difficulty, especially when large quantities of metal are to be treated. In treating a 3-lb. melt by the Rosenhain method, a rate of addition of not more than 2 c.c. per min. must not be exceeded in order to avoid excessive evolution of fume.

Table VII gives the result of experiments made with 3-lb. melts in the electric furnace. Treatment was commenced immediately after melting and continued for about 15 min. as the temperature rose to 700 deg. C.—that employed for casting. Most of the experiments were made using 4 c.c. of titanium tetrachloride per lb. of alloy, an amount which Rosenhain, Grogan and Schofield have shown to give satisfactory results.

An increase in density is observed with all alloys treated except with the "3L11" alloy treated by the second method. The treatment appears to be more successful when the Rosenhain method is used.

"Y" alloy is rendered practically sound by this treatment; the 12 per cent. silicon alloy is improved considerably; "2L5" alloy and "3L11" alloy are improved, but only to a moderate extent. The visual appearance of sections of alloys treated with titanium tetrachloride is not a reliable guide to soundness, since they are sometimes much less sound than they appear to be, as is well indicated by the density tests. This is due to the marked grain refinement produced by titanium tetrachloride, which refines the unsoundness as well as the grain size, and reduces the size of the holes below the limit of visibility even when the total unsoundness is not reduced by treatment. For example, with ingot No. 65 a very marked reduction in density has occurred, yet the visual appearance of the section is much improved. Examination under a low-power magnification shows the presence of a very large number of pinholes of small dimensions; these are illustrated in No. 65. "Y" alloy is more amenable to treatment by titanium chloride than are the other alloys. This may be due to the presence of magnesium in this alloy.

### Effect of the Presence of a Constituent having a Relatively High Vapour Pressure.

It was thought that advantage might be taken of the presence of a constituent having a relatively high partial pressure in a molten alloy to disturb the equilibrium existing between the metal and the gas held in solution. In the case of the "2L5" alloy, which has a zinc content of more than 12 per cent. (zinc boiling point 906 deg. C.), this constituent should exert a considerable partial pressure in the alloy at the more elevated temperatures. Three lbs. of the M. "2L5" alloy were heated in the electric furnace to a temperature of 950 deg. C. and held there for 1 hr., the melt being stirred vigorously from time to time. Some zinc volatilised, as was shown by spurts of blue flame from the surface of the melt on agitation. The melt thus treated was allowed to cool to 750 deg. C. before casting. This experiment was duplicated, with the following results:—

| | Density. |
|---|---|
| Ingot No. 71. "2L5" alloy not treated ... ... ... | 2.900 |
| Ingot No. 83. "2L5" alloy treated as above ... ... | 2.929 |
| Ingot No. 88. "2L5" alloy treated as above ... ... | 2.938 |

(Ingot No. 88 is illustrated in Fig. 17.)

The treated ingots are practically free from pinholes, and show an increase in density; they do not exhibit, to any marked extent, the central shrinkage cavity.

### Effect of Cadmium.

Cadmium has a relatively low boiling-point of 767 deg. C., and is soluble in pure aluminium to only a limited extent. Its presence in aluminium alloys is stated not to be deleterious. In the following experiments quantities of up to 1 per cent. cadmium were added to 3-lb. melts of the "3L11" alloy heated in the electric furnace. The addition was made immediately on melting, the alloy being stirred occasionally as the temperature rose to 800 deg. C. After 30 min. at this temperature, the melt was allowed to cool to the casting temperature of 700 deg. C. There was no visible evidence of a reaction between the melt and the added cadmium.

Three melts were treated, with the results as shown in Table VIII.

Table VIII.—*Effect of Cadmium on Soundness.*

| Ingot No. | Material. | Treatment. Addition of: | Density. | Appearance. |
|---|---|---|---|---|
| 66 | M. "3L11" | 1 per cent. cadmium | 2.841 | Moderate. |
| 67 | M. "3L11" | 0.1 per cent. cadmium | 2.820 | ,, |
| 70 | M. "3L11" | 0.5 per cent. cadmium | 2.833 | ,, |

Little change in the amount of pinholing has occurred. The pinholes present appeared to be less rounded and more angular. The increase observed in density is accounted for by cadmium (density 8.6) retained in the casting.

### Effects of Sulphur, Selenium and Tellurium.

Elements of this group form compounds with aluminium which are stated to be insoluble in liquid aluminium. They also form fairly stable hydrides by direct union of the elements. The boiling point of sulphur is 444 deg. C., and that of selenium 680 deg. C.

It appeared possible that additions of these elements to aluminium melts containing dissolved gases would disturb the equilibrium between the melts and the gas held in solution. In the following experiments additions of quantities up to 1 per cent. of the three elements were made to 3-lb. melts of the various aluminium allows.

### Sulphur.

Sulphur was added in the form of the ordinary commercial lump; 3 or 4 grm. at a time were stirred into the melt held at 750 deg. C. by means of an inverted crucible mounted on a steel rod. Bubbles of gas, accompanied by the flame of burning sulphur, were evolved freely during treatment. The melts were allowed to cool to 700 deg. C. before casting. A considerable quantity of dross was found which was yellow whilst hot, and turned grey on cooling. On casting, and just before solidification, a considerable evolution of gas from the metal occurred, which is indicative of a probable unsound ingot.

Particulars of the treatments made are given in Table IX.

The addition of 1 per cent. sulphur under these conditions results in the production of a very bad pinholed casting having a reduced density.

### Selenium.

Vitreous selenium was added to 3-lb. melts in a manner exactly similar to that used for sulphur. A less vigorous reaction ensued on making the additions. Fumes varying with their density from green to reddish-brown violet were evolved from the melt. These fumes were found to have a very objectionable physiological action. No gas was evolved from the ingots on casting. The treatments are given in Table X.

Table IX.—*Influence of Sulphur on Soundness.*

| Ingot No. | Material. | Treatment. Addition of: | Density. | Appearance. |
|---|---|---|---|---|
| 93 | M. "3L11" | 1 per cent. sulphur at 750 deg. C. | 2.764 | Very unsound. |
| 94 | M. "3L11" | 1 per cent. sulphur at 900 deg. C. | 2.737 | ,, ,, |
| 95 | M. Si .. | 1 per cent. sulphur at 750 deg. C. | 2.573 | ,, ,, |
| 96 | M. "2L5" | ,, ,, | 2.848 | ,, ,, |

Table X.—*Effect of Selenium on Soundness.*

| Ingot No. | Material. | Treatment. Addition of: | Density. | Appearance. |
|---|---|---|---|---|
| 100 | M. "3L11" | 1 per cent. selenium at 750 deg. C. | 2.781 | Several very small pinholes. |
| 101 | M. "3L11" | 0.1 per cent. selenium at 750 deg. C. | 2.786 | ,, ,, |
| 102 | M. "Y" .. | 1 per cent. selenium at 750 deg. C. | 2.726 | ,, ,, |
| 103 | M. "Y" .. | 0.1 per cent. selenium at 750 deg .C. | 2.718 | ,, ,, |
| 105 | M. Si .. | 0.1 per cent. selenium at 750 deg. C. | 2.600 | Few large pinholes. |
| 106 | M. "2L5".. | 0.1 per cent. selenium at 750 deg. C. | 2.864 | Several large pinholes. |

Ingot No. 101 is illustrated in Fig. 18. The smallness of the pinholes in ingot No. 101 has precluded their printing up and reproduction. The appearance of ingots in "3L11" and "Y"-alloy treated with selenium is distinctly better than that of untreated metal, although an improvement in density is shown only with the "Y"-alloy. The pinholes in these ingots, on examination under the microscope, are found to be small, elongated and angular.

### Tellurium.

The metallic tellurium was added in a manner similar to that used for sulphur and selenium. No reaction accompanies the addition, but, on stirring, a gritty slag is found at the bottom of the crucible. Melts treated with tellurium were stirred vigorously to incorporate the apparently insoluble compound formed. Treatments were carried out as shown in Table XI, the ingots being cast at 700 deg. C.

A section of ingot No. 86 is illustrated in Fig. 19. A marked improvement with "Y"-alloy and with "2L5" alloy, is observed both in density and appearance. The appearance of the "3L11" alloy is also visually improved, due to the marked reduction in the size of the pinholes; the density of the treated "3L11" alloy is, however, in most cases, less than that of untreated metal. In view of the fairly promising results obtained in the case of melts treated with tellurium, and the simplicity of its application, it was decided to investigate the properties of the treated alloys further. A spectrographic examination was made to determine the presence or segregation, if any, of tellurium in the ingot, but its presence was observed only in the one specimen, from an ingot to which 1 per cent. tellurium had been added.

### Tensile Tests.

Melts of M. "3L11" alloy and M. "Y"-alloy were treated with various percentages of tellurium under conditions identical with those described previously. The addition of selenium to the "3L11" alloy was also made. Four test-bars were cast from each melt, two in skin-dried green-sand moulds, 1.125 in. dia. × 6 in. long (S) and two in hand warm chills 1 in. dia. × 6 in. long (C). The test-bars were turned down to a test dia. of 0.564 in. on a gauge length of 2 in. and broken. The yield point was determined by visual observation, using dividers, a method which does not give highly satisfactory results with these alloys. A summary of the results obtained is given in Table XII. Tellurium and selenium are seen to have a very deleterious effect on the tensile properties of sand-cast bars in "3L11" alloy, the ultimate strength being reduced by some 40 per cent. This reduction in strength accompanies the addition of only 0.1 per cent. tellurium, and remains practically unaltered for further amounts. The effect on the chill-cast bars is relatively small and inappreciable. "Y"-alloy appears to suffer no deterioration in tensile properties by the addition of 0.25 per cent. tellurium, either in the sand-cast or in the chill-cast bars.

Table XI.—*Influence of Tellurium on Soundness.*

| Ingot No. | Material. | Treatment. Addition of: | Density. | Appearance. |
|---|---|---|---|---|
| 86 | M. "3L11" | 1 per cent. tellurium at 750 deg. C. | 2.800 | Very small pinholes. Moderate. |
| 97 | M. "3L11" | 0.5 " " " .. | 2.804 | Very small pinholes. Few. |
| 98 | M. "3L11" | 0.25 " " " .. | 2.791 | Very small pinholes. Moderate. |
| 90 | M. "3L11" | 0.1 " " " .. | 2.797 | Very small pinholes. Several. |
| 84 | M. "3L11" | 1 " " 800 deg. C. | 2.817 | Very small pinholes. Moderate. |
| 85 | M. "3L11" | 1 " " 900 deg. C. | 2.807 | " " " |
| 91 | M. "2L5" .. | 1 " " 750 deg. C. | 2.911 | Few small pinholes. Extensive contraction cavities. |
| 99 | M. "2L5" .. | 0.1 " " " .. | 2.933 | " " " |
| 87 | M. Si .. | 1 " " " .. | 2.589 | Few large pinholes. |
| 104 | M. Si .. | 0.1 " " " .. | 2.590 | Several large pinholes. |
| 89 | M. "Y" .. | 1 " " " .. | 2.738 | Very small pinholes. Practically sound. |
| 92 | M. "Y" .. | 0.1 " " " .. | 2.730 | " " " |

Table XII.—*Tensile Tests on Tellurium and Selenium Treated Alloys.*

| No. | Alloy. | Treatment. | Yield point. Tons/sq. in. | Ultimate strength. Tons/sq. in. | Elongation. Per cent. on 2 in. |
|---|---|---|---|---|---|
| 108C | "3L11" | None .. .. | 5.44 | 10.96 | 5 |
| " | " | " .. .. | 7.36 | 10.0 | 3 |
| 108S | " | " .. .. | 4.16 | 7.36 | 2½ |
| " | " | " .. .. | 5.0 | 7.36 | 1 |
| 109C | " | Addition of 1 per cent. tellurium | — | 10.0 | 4 |
| " | " | " " | 5.04 | 9.84 | 4 |
| 109S | " | " " | 3.48 | 4.8 | 1 |
| " | " | " " | 3.2 | 4.64 | 1 |
| 110C | " | Addition of 0.1 per cent. tellurium | 2.88 | 10.60 | 3½ |
| " | " | " " | 3.36 | 11.80 | 5 |
| 110S | " | " " | 4.20 | 5.28 | 1½ |
| " | " | " " | 4.0 | 4.60 | 1 |
| 111C | " | Addition of 0.5 per cent. tellurium | 5.48 | 10.0 | 3 |
| " | — | " " | — | — | — |
| 111S | "3L11" | " " | 4.24 | 4.72 | 2 |
| " | " | " " | 4.0 | 4.88 | 1½ |
| 112C | " | Addition of 0.2 per cent. tellurium* | 5.28 | 7.6 | 3 |
| " | " | " " | 5.52 | 8.0 | 2 |
| 112S | " | " " | 1.6 | 4.24 | 1 |
| " | " | " " | 4.0 | 4.52 | 2 |
| 113C | "Y"-alloy | None .. .. | 8.0 | 10.28 | 2 |
| " | " | " .. .. | 8.4 | 10.64 | 2 |
| 113S | " | " .. .. | 6.12 | 9.76 | 2 |
| " | " | " .. .. | 6.8 | 9.80 | 2 |
| 114C | " | Addition of 0.25 per cent. tellurium | 7.32 | 10.40 | 2½ |
| " | " | " " | 7.2 | 9.52 | 2 |
| 114S | " | " " | 8.8 | 10.32 | 2 |
| " | " | " " | 8.8 | 10.44 | 2 |
| 115C | "3L11" | Addition of 0.25 per cent. selenium | 4.80 | 7.5 | 4 |
| " | " | " " | 4.0 | 10.16 | 4 |
| 115S | " | " " | 4.4 | 5.2 | 1 |
| " | " | " " | 3.40 | 5.52 | 1 |

* Tellurium introduced via a tin–tellurium alloy containing 33⅓ per cent. tellurium.

### Experiments using a Heated Dozzle when Casting.

It has been suggested that shrinkage during solidification might be an important contributory factor in the production of pinholes in the castings. With the taper casting used, cooling commences more or less equally from all faces, with the result that the final areas to solidify are surrounded completely by solid metal already possessing some degree of rigidity, which would tend to oppose the progressive contraction of the still liquid and cooling portions. An attempt to produce progressive solidification from the taper end upwards, and thus eliminate effects of solidification shrinkage, was made by the use of a heavy cast-iron dozzle heated to redness and placed symmetrically on the top of the mould immediately before casting. Details of the dozzle are given in Fig. 3.

Virgin aluminium ingot and "3L11" alloy were melted and cast at 700 deg. C. without treatment. The results of these experiments are given in Table XIII.

Table XIII.

| Ingot No. | Material. | Treatment. | Density. | Appearance. |
|---|---|---|---|---|
| 17 | M. "3L11" .. | Standard test ingot .. .. .. | 2.810 | Moderate pinholing. |
| 30 | " .. | Cast 700 deg. C. Dozzle heated to 750 deg. C. | 2.790 | Slightly worse. |
| 33 | " .. | Cast 700 deg. C. Dozzle heated to 950 deg. C. | 2.791 | " " |
| 12 | Virgin aluminium ingot | Standard test ingot .. .. .. | 2.673 | Practically sound. |
| 31 | " " | Cast 700 deg. C. Dozzle heated to 750 deg. C. | 2.665 | Slight unsoundness. |

Ingot No. 33 is illustrated in Fig. 9.

The use of a dozzle appears to have little effect on the production of pinholes—resulting, in fact, in slightly less satisfactory results, which may be due to the metal cooling more slowly under these conditions.

### Unsoundness near Edge of Test Ingots.

Although in general the size of the pinholes in the test castings appears to be at a maximum at the centre of the ingot, some large cavities were usually observed near the edges. These are particularly noticeable in the sounder ingots, as visual examination will show. It is scarcely probable that these are normal pinholes, and it is thought that they are due to other effects. Similar cavities have been observed in chill-cast aluminium-alloy ingots, which, although pinhole-free in the centre, show these subcutaneous cavities. In view of the well-marked effect of steam, it was thought that these might be due to reaction of the alloy with moisture given off by the surface of the mould.

### Use of Stove-Dried Moulds.

In the laboratory experiments reported upon previously, skin-dried green-sand moulds were used. The depth of the dried area of sand in such moulds is quite small, the remainder of the sand still retaining the 5 to 10 per cent. of moisture originally present. A possibility arises that water vapour from this damp sand after casting will react with the still liquid metal in the mould and will give rise to unsoundness similar to that obtained in the water-vapour experiments. Some stove-dried moulds were prepared and castings in M. "3L11" poured at 700 deg. C., with the following results:—

| Ingot No. | Mould. | Density. |
|---|---|---|
| 17 | Skin-dried .. | 2.810 |
| 40 | Stove-dried .. | 2.819 |
| 43 | " .. | 2.817 |

The use of a completely dried mould appears to effect a slight increase in density. In view of the results of these experiments, it was decided to include stove-dried moulds in further tests. This was carried out in the works experiments using 60-lb. experimental melts. (See Table V.) No very regular or appreciable difference in density between castings poured in the green-sand and the stove-dried moulds is apparent, but the experiment is scarcely conclusive, as normal stove-drying will undoubtedly leave a considerable amount of adsorbed or combined water in the sand. Further experiments are required to test the validity of the hypothesis.

### Metallographic Examination of Pinholes in "3L11" Alloy.

The size, number and shape of the pinholes which occur in the "3L11" alloy (8 per cent. copper-aluminium) depend on the melting conditions, treatment, when molten, and the casting conditions to which the metal is subjected. This is illustrated by the several full-size sections examined and reported on elsewhere. Two of the castings were taken for examination in more detail, microsections being cut from No. 5 ingot (stock "3L11" alloy melted in electric furnace and cast at 700 deg. C.) and from No. 8 ingot (stock "3L11" alloy melted in electric furnace and heated to 700 deg. C., when a brisk stream of steam was bubbled into the melt for 3 min.).

The microsections were prepared in the usual manner for this type of alloy, but complete elimination of scratches, especially from the vicinity of the pinholes, was found to be practically impossible, due apparently to the secretion of coarse particles of abrasive from earlier operations in these areas, which no amount of washing and scouring seemed to remove. For etching, an aqueous solution containing 2 per cent. hydrofluoric acid and 25 per cent. nitric acid was used.

Pinholes are found to vary from ill-defined cracks and voids occurring in the areas normally occupied by the $CuAl_2$ eutectic, to cavities generally of an irregular spherical shape up to 1 mm. or more across. Examination of the larger pinholes under the lower-power binocular microscope showed that these cavities have a regular cell-like formation, the bounding walls being

formed of the aluminium-rich constituent standing in relief surrounded by darker rings of the $CuAl_2$ eutectic, similar in formation to the normal microstructure. It is to be observed that pinholing follows the crystallisation of the eutectic at the grain boundaries, but bears no general relationship to grain size, except where the latter is very small.

The reason for this difference in structure must be sought for in a consideration of the influence of the amount of gas liberated on solidification in the two melts. This is a function of the amount of gas held in solution in the melt and its decrease in solubility with fall in temperature. Whether voids would, or would not, occur at eutectic and grain boundaries in a gas-free melt is a matter difficult to determine. There will be present a state of stress at these areas due to contraction on solidification, since with the casting under consideration, solidification commences more or less equally and simultaneously from all faces. Gases evolved during solidification, and not escaping from the melt, will naturally segregate with the still liquid portions —namely, with the eutectic at grain boundaries— and when present in sufficient quantity will be associated with a visible intereutectic crack. The greater the amount of gas evolved the larger will be the crack, and should its quantity be sufficient to assume an appreciable positive pressure, the void created may be expected to assume a more approximate spherical shape. Thus when small quantities of gas are thrown out of solution on solidification, the voids obtained will be of the crack-like intereutectic type. With large evolutions of gas, well-defined spherical cavities will result.

In the light of this argument, it may be concluded that sufficient gas has been evolved on solidification with the No. 8 ingot to create quite a considerable positive pressure resulting in the well-defined spherical cavities observed.

### Conclusions.

Water vapour, either in the furnace atmosphere or bubbled into the molten alloy, is found to be very deleterious, rapidly giving rise to extensive pinholing and unsoundness. Treatment with dry nitrogen or chlorine will usually effect an improvement in soundness. A mixture in equal proportions of the two gases gives results superior to those obtained by either of the gases used separately, or consecutively. The temperature at which the melt is treated is found to be a very important factor. The most satisfactory results are obtained at temperatures just above the melting point of the alloy. A gas treatment with the chlorine-nitrogen mixture at a temperature of 700 deg. C. or below for a period of 10 min. will effectively remove all visual pinholing and unsoundness from a 3-lb. melt in the electric furnace.

Works-scale experiments using a 60-lb. charge in an oil-fired plumbago crucible yield results which agree well with the laboratory experiments. With 300-lb. melts in a gas-fired furnace it is found that fairly satisfactory results are obtainable when the temperature does not exceed 700 deg. C. On heating to a pouring temperature of 760 deg. C. and continuing the gas treatment (chlorine and nitrogen) much less satisfactory results were obtained. It would appear that at these temperatures, with gas-fired melting pots, the rate of deterioration of the metal due to the absorption of furnace gases is more rapid than the beneficial action of the chlorine and nitrogen treatment. Treatment of a 3-lb. melt with tetrachloride in the electric furnace is found effective in reducing grain size. With "Y"-alloy the treatment has removed practically all pinholing originally present, but has been less effective with the 12 per cent. silicon alloy, "2L5" alloy and "3L11" alloy—the last two showing least improvement. Much fume is evolved from the melt unless the rate of addition of the liquid titanium tetrachloride is suitably slow.

By heating "2L5" alloy at 950 deg. C. in the electric furnace and stirring vigorously, so that some of the zinc vaporises, a casting can be obtained practically free from pinholes. The addition of up to 1 per cent. cadmium to a melt held at a temperature above the boiling point of cadmium is not similarly effective. Sulphur, selenium and tellurium are insoluble in aluminium, and can form hydrides by direct union of the elements. Quantities of these elements up to 1 per cent. have been added to 3-lb. melts. Sulphur gives rise to increased unsoundness. With selenium and tellurium the results obtained were irregular; in some instances an appreciable improvement in soundness was noted. These elements have a deleterious effect on physical properties, especially of sand-cast bars in the "3L11" alloy.

It has been observed that, in laboratory experiments, castings poured in stove-dried moulds have a slightly higher density than those poured in skin-dried green-sand moulds. The appearance of larger cavities near to the edges of aluminium castings has been noted. These cavities do not appear to be normal pinholes. Metallographic examination of test castings in the "3L11" alloy has provided information regarding the variations in character, size and shape of pinholes in variously treated melts.

## Book Review.

**Praktische Berechnungen des Giessereimannes,** by E. Schütz. Published by Wilhelm Knapp, Verlagsbuchhandlung Halle (Saale), Germany. Price 13.5 marks (paper cover).

Translated, the title of this book reads "Practical Calculations for the Use of Foundrymen." It covers the calculation of sizes for box lugs; serrated beams for lifting boxes, moulding and core-box thicknesses (perhaps a study of this would eliminate the number of cracked boxes one sees in many jobbing foundries), core arbours, box clamps, pressure of liquid iron, strength of chaplets, crane and beam hooks, cost of liquid iron, cupola practice, working costs, calculation of mixtures, cast-iron columns, weight of cast sections, cast-iron window frames, thickness of pulleys, flywheels, rope and grooved pulleys, gear wheels and hollow bodies under pressure. The final section is a comprehensive selection of tables for ready reckoning.

We can pay no higher compliment to this book than to say that we wish a similar book was available in the English language. It would certainly be most helpful to the average foundry executive in computing weights and strengths.

## Full-Time Foundry and Metallurgical Courses.

The Constantine Technical College, Middlesbrough, has organised a very complete foundry educational course for day students. It is of two years' duration and will, we believe, carry diplomas endorsed by the Institute of British Foundrymen for those successfully passing its examinations. The principal, Dr. T. J. Murray, the head of the metallurgical department, or Mr. C. R. Groves will be pleased to furnish applicants with details of the syllabus. From personal inspection, we can assure parents that the equipment is of the highest order.

**New Process for Protecting Iron against Rust.**—According to a German communication a process for protecting iron against rust has lately been developed in Germany, for which it is claimed that it does not deteriorate the physical properties of the metal. The iron object after being thoroughly cleaned is dipped into a 2½ per cent. solution of phosphoric-acid salts of a certain composition and allowed to remain therein for about half-an-hour to an hour, the temperature of the solution being maintained at 100 deg. C. all the while. The iron becomes thereby coated with an "extraordinarily dense" film, which does not dissolve in water. According to available information, the process has been well known for some time, but has only recently been perfected.—"Reichszentrale für Wissenschaftliche Berichterstattung."

## Problems for Copper Buyers.

By "Onlooker."

The immediate result of the announcement that Britain had suspended the gold standard was to create something of a topsy-turvy state of affairs in the metal markets, and for the first few hours it was practically impossible to obtain quotations for any of the non-ferrous metals. There were rumours that the Metal Exchange would follow the lead of the Stock Exchange, and remain closed, but the doors opened as usual and dealings began with customary promptitude on the stroke of twelve; nor was there any indication of panic dealing during the session.

Naturally, the tendency of all metals was upwards, and, although copper started off quietly, values soared during the closing period, and a gain of £5 was seen at the end of the session. Tin improved by £8, spelter by £1 and lead by £2. A remarkable reversal after the downward sweep of the past few months, and it is not strange that the feeling has been more optimistic, even though it be realised that the rise is to a great extent due to the depreciation in the dollar exchange rate. In contradiction to this, tin must be cited as an example of a metal not dependent upon the vagaries of exchange, and the rise in tin following upon the departure from the gold standard has been remarkable, for a quotation well on the way to £140 was achieved.

With the exception of copper, the non-ferrous metals have all been quoted in sterling to consumers prepared to purchase, but lead and spelter have been offered at prices which left a margin for covering exchange, and the increasing fluctuation in the dollar rate has been a factor of great difficulty to buyers and sellers alike. The dominant body in copper, Copper Exporters Incorporated, have, however, taken a different view, and their sales agents in this country were evidently instructed to keep to American currency, as a result of which 7½ cents was the ruling price at which consumers were invited to purchase. The Metal Exchange has, of course, registered daily a price of electrolytic, and interests outside the combine have been offering a limited tonnage in sterling, but so far buyers have done little, and the business secured by the United States has been meagre.

At the time of writing, this "Americanisation" of the copper business in Britain continues, and to some extent the disease has spread to scrap metals, for this country has come to depend a good deal on the States for its old metals, and dealers who import from America have followed the lead of the Exporters and refused to offer their wares except in cents per pound. It looks very much as if the Export Association will endeavour to continue to quote in the currency of the country of origin, in which case it may be assumed that consumers here will give all the business they possibly can to merchants and dealers trading apart from the American price ring, and will, furthermore, take a much greater interest in high-grade scrap of British origin than has been the case of late. Nevertheless, the problem is a serious one for our consuming trades, and it is much to be feared that the first results of this stubborn adherence to the dollar quotation will be to check business in the red metal.

At a time like the present, the London Metal Exchange quotations are of inestimable value, but not unnaturally prices have fluctuated very widely from day to day, and this has made manufacturers very careful in quoting to their customers. The standard market may be utilised as a hedge, but at abnormal times dealing in standard is a somewhat dangerous job and may easily prove a costly experiment.

**When riveting** aluminium or aluminium-alloy sheets, rivets of the same composition as the sheets should be used.

# Foundry Selling Practice.

**By Eric N. Simons.**

(*Continued from page* 131.)

### No. 8. SATISFYING THE CUSTOMER.

Buyers of castings are not necessarily the people who use them, but from the foundry point of view, the buyer is a buyer, and has to be satisfied, whether he actually uses the castings or not. The days when the purchaser had to take what he could get have gone, and on the whole it is as well. The customer and his attitude are of prime importance. Whatever the excellence of the castings, their lasting power, their price, their finish, what finally decides the question of whether they are bought is the feeling of the customer towards the foundry that produces them.

Customers, whether consumers or not, will have opinions, favourable or otherwise, on the firm, the castings, the selling methods and so forth. And these opinions will be far franker (and therefore more revealing) than the opinions of the men who make the castings or the men who sell them. Complaints are sure to be made here and there. Many will be of no value, mere examples of prejudice or superstition. But a larger number than many foundries are willing to admit will have a foundation in fact, and special attention should be paid to these. What is singular is that often these complaints do not materialise until some authoritative executive has actually visited the customer. The salesman usually works through the buyer, and often complaints by the actual user do not get through these intermediaries to the actual foundry. The explanation is partly that both selling and buying departments are to some extent out of touch with the works, and partly that the representative may have reasons for not conveying complaints, or the buyer be insufficiently technical to pass on the criticisms without revealing his own ignorance, in any consequent discussion.

Complaints are not all works complaints. If the castings are part of a manufacturer's product, the complaint may come from his sales department, as, for example, if the finish of the job leaves something to be desired. The founder must, therefore, realise that he has not necessarily done everything when he has satisfied the works.

Nothing is more illuminating and helpful than an analysis of why satisfied customers are satisfied. The founder wants people to buy his goods and to go on buying them, and wants to find fresh people to buy them. Every reason a customer has for being satisfied is, *in posse*, an argument why another customer should buy. A point to be made here is that one man's reasons alone are insufficient. Every satisfied customer —or a representative selection—should contribute some reason for his satisfaction. Where there are complaints, the sales manager should consider whether they are of long standing, whether they can be obviated, etc.

#### Satisfying the Customer.

Now, what are the main elements in satisfying a customer? Briefly, they may be tabulated as follow:—

(1) *Habit or Custom.*—Many people continue buying a particular type of casting from a particular firm because it has always been the habit or custom or rule of the firm to go to that place for that particular product. This only obtains when good service at reasonable prices has been given over a long period. Hence, fair treatment steadily maintained is the first element in satisfying the customer.

(2)—*The Personal Touch.*—This does not necessarily mean free "entertainment." It means that element in a customer which makes him like the salesman or other officials of the foundry, and that element in the salesman or officials that arouses that liking. Foundries should, therefore, choose representatives with pleasing personalities, men whom they can trust to be courteous, friendly, intelligent and frank, to all their customers, of whatever standing.

(3) *Deliveries.*—Nothing satisfies a customer better than quick and prompt deliveries. If a firm has a name for being exemplary in this way, it will get many an order that other considerations might cause to be placed elsewhere. Especially is this important to-day, when buyers order from hand to mouth, and need their purchases urgently when they screw up their courage to make them.

(4) *Situation.*—Customers have many reasons for liking to place their orders in their own district. They may be large ratepayers, and dislike sending work out of the city. They find it an advantage to be able to telephone cheaply and quickly when they want to alter or inquire about an order. They are able to send people along to see the castings. An efficient sales manager will, therefore, make sure that he is reaping the benefit of this strong pull, and is getting all the local orders that he should get. Generally, orders are placed with firms further off mainly because the local founder has tended to trade too much on his ready-made advantages, and has neglected the other essentials in satisfying his customer.

#### Elements of Price and Terms of Payment.

(5) *Fair Prices.*—There are customers who make price and not quality their fixed consideration. There are others who buy on quality only, and care little about price. But the majority buy castings of the best quality they can get for the price they can afford to pay. If the foundry can quote lower prices than its competitors without cutting quality, it should have no difficulty in getting orders. Hence the need for ruthless and efficient costing, and for the elimination of waste and excessive overhead charges. Generally, price for equal quality does not vary much. If it does, then the founder who is not getting the orders because his prices are too high is probably working with a defective organisation and should inquire into the matter.

(6) *Good Terms.*—The amount of credit a firm will give and the eagerness with which it presses for payment both affect a customer's attitude towards it. Many customers desiring easy payment terms are genuine. Some are not and to trust them is an error. Usually, the firm that has been most badly hit is the one most stringent in its terms. The whole subject is a difficult one, and the founder should try to work as far as possible without set rules, which may at times be applied unthinkingly and with ill effect. Each case should be taken on its merits, and leniency rightly applied is always a good selling factor.

(7) *Quality.*—Quality is always a cause for satisfaction, but even more so when the quality is steadily maintained, so that uniformity in this respect can be relied upon. But the founder should remember that it does not take many bad castings to destroy this reputation. Hence, he should never fall into the error of neglecting his old customers and failing to preserve a high standard of workmanship and supervision.

(8) *Publicity.*—Much despised by the unthinking, it yet remains a fact that publicity wins customers for a firm as against its rivals. There is no golden rule to success in this respect, except that the publicity is expensive, important, and should be carried out by an expert, not by the manager himself (unless he has been trained for the job). How insidious is the effect of publicity can best be indicated by an example. The author, who has no reason to remember the name of anyone making malleable castings, has never had occasion to buy any, and on whom, one might say, any firm advertising these goods had wasted its efforts, was asked by a foreign firm the name of a good maker of malleable castings to whom they could send an inquiry. The author answered promptly: "Oh, Y's." He knew nothing about Y's, except that somehow, through publicity, that firm had thrust its name into his memory and associated it for ever with good malleable castings. And ultimately that fact was useful to them. Hence the value of publicity. There is also the point that many firms like to buy from a foundry well known and of good repute. They gain from the publicity of others.

(*To be continued.*)

## Notes from I.B.F. Branches.

*West Riding of Yorkshire Branch.*—The syllabus of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, for the coming session, is a particularly interesting one. A change of custom which should be noted is that the meetings, in the main, are on the second Saturday of the month, instead of—as in previous years—the first Saturday. The session opens on October 10, when Mr. A. S. Worcester will present his Presidential Address. On November 14 members will visit the works of Dean, Smith & Grace, Limited, one of the best-known of Keighley engineering undertakings. The December meeting is to be reserved as the customary open meeting for the free discussion of members' foundry problems. The new year, it is hoped, will be opened with the first annual dinner of the Branch on January 9. Dr. H. W. Swift, M.A., B.Sc., M.I.Mech.E., head of the engineering department of Bradford Technical College, who contributed some valuable material to the Branch last year, has again consented to give a Paper, the subject of which is "Some Physical Properties of Cast Iron," on February 13. Members are to visit the works of Thos. Broadbent & Sons, Limited, engineers, Huddersfield, on March 12, and on April 9 Mr. H. Forrest will speak on "Some Aspects of Steel Foundings." The session will be brought to a close on April 30 by the annual general meeting and election of officers.

The technical reference library of the Branch is steadily increasing, and now numbers 40 valuable works. The Branch is keenly interested in furthering the Institute's Craft Certificate Scheme, in which the co-operation of the Bradford Technical College has been assured.

**A mixture** composed of one part of caustic soda, three parts of resin, three parts of plaster of Paris and five parts of water, boiled together, can be used to cement brass to either brass or glass.

**Low-Melting-Point Brazing Alloy.**—A new brazing alloy containing a small percentage of silver and described as flowing freely at 705 deg. C. is being marketed by Handy & Harman, 57, William Street, New York, under the trade name of "Sil Fos." It is for use where higher melting point base-metal brazing or welding alloys cannot be employed without danger of weakening, distorting or destroying the parts adjacent to the joint. Deep and quick penetration, due to the silver in the alloy, is also claimed. In addition, it is pointed out that at 760 deg. C. the flow point of borax flux with which it is generally applied, there is 55 deg. of superheat, which increases the fluidity still further and aids penetration and alloying action. Less than the usual amount of flux is said to be required because of the deoxidising effect of the phosphorus in the alloy, and this tends to reduce the cost of cleaning and finishing after joints have been made. Under certain conditions, satisfactory copper to copper joints can be made without using any flux.—"The Iron Age."

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# This Week's News in Brief.

## Trade Talk.

Employees of Anderson, Boyes & Company, Limited, Motherwell, have contributed £219 to infirmaries and other institutions in the West of Scotland.

"Corfu," a turbine steamer of 14,000 tons, built by Alexander Stephen & Sons, Limited, for the P. and O. Line, has completed successful trials on the Clyde.

Considerable damage was caused by fire at the Daisy Lane lead warehouse of James Chew & Company, Limited, brass and aluminium founders, Brookhouse, Blackburn. Over twenty tons of lead piping were damaged.

The Birtley Company, Limited, Birtley, Co. Durham, announced on Monday that they have secured a contract from Russia for a patent coal-cleaning plant, which is to be installed at the Donetz Basin, Russia.

The London Chamber of Commerce has informed the Prime Minister that more than half its members have now replied to a questionnaire on tariffs, and that, of the 4,534 replies, 90.56 per cent. favour the immediate imposition of duties.

The Students' Section of the Institution of Engineers and Shipbuilders in Scotland paid a visit to Belfast last month, inspecting the works of Harland & Wolff, Limited, Davidson & Company, Limited, and the York Street Flax Spinning Company. The party was received by the Lord Mayor of Belfast.

The Dutch Foundry Technical Association (Nederlandsche Vereeniging Van Gielerij-Technici) is holding its annual meeting this month, and Mr. A. A. Grubb, of Messrs. Grubb & Marshall, Columbus, Ohio, is presenting a Paper on sand control on behalf of the American Foundrymen's Association.

Alex. Hall & Company, Limited, Footdee, Aberdeen, have received orders from British owners for two sea-going tugs and for a 95-ft. drifter. The Caledon Shipbuilding & Engineering Company, Limited, Dundee, have secured an order for a steamer, 210 ft. in length, for the Limerick Steamship Company, Limited.

Messrs. Blackstone & Company, Limited, Stamford, have received a contract for the supply and erection of the whole of the machinery required for the Eastleigh and Bishopstoke sewerage scheme called for under the engineer's contract No. 2. The value of the contract is approximately £14,000.

Electrical apparatus and machinery weighing 1,382 tons are being consigned to Hungary by the Metropolitan-Vickers Electrical Company, Limited, in connection with the contract for the electrification of 80 miles of line on the Hungarian State Railways. Arrangements for transport have been made by the L.N.E. Railway and the Harwich-Zeebrugge train ferry companies.

At an extraordinary general meeting of the Cronite Foundry Company, Limited, held on September 16, a resolution was passed approving the scheme of arrangement with the shareholders sanctioned by the High Court of Justice on June 22 last. It was resolved that the company be wound up voluntarily, and that Mr. W. J. Chanter, 5, Victoria Street, London, S.W.1, be appointed liquidator, and that the liquidator be authorised to consent to the registration of a new company to be called "The Cronite Foundry Company, Limited."

Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield, have received a contract from Cement Industries, Limited, for the supply and erection of a complete Portland-cement plant which will be situated at Asheham, near Lewes, Sussex. The factory is designed for an ultimate capacity of 180,000 tons per annum, and will comprise three units of 60,000 tons, the first of which is now being installed. The factory will concentrate on the production of rapid-hardening cement, and will be equipped with the most modern plant, such as the recuperator-type rotary kiln, the Rexman balanced-rod mills and the Fuller-Kinyon cement-conveying equipment. In addition, a Schulthess lime-hydrating plant is being installed in connection with the existing lime plant, which is being enlarged.

Textile Machinery Makers, Limited, was registered as a public company last week. It has been formed in accordance with a scheme, prepared by Sir Gilbert Garnsey, for the amalgamation of a group of textile machinery making firms, which scheme, as already announced, was accepted in principle by each company some months ago. The new company has been formed to acquire the land, buildings, machinery, manufacturing, and ancillary undertakings and businesses of Asa Lees & Company, Limited, Brooks & Doxey (1920), Limited, Dobson & Barlow, Limited, Howard & Bullough, Limited, John Hetherington & Sons, Limited, and Platt Bros. & Company, Limited, and to carry on the business of metal founders and workers, engineers, millwrights, machinery manufacturers, etc. Registration details will be found under "New Companies."

New Government contracts listed in the "Ministry of Labour Gazette" include the following:—*Admiralty.*—Anchors: S. Taylor & Sons (Brierley Hill), Limited. Camshafts and cams: William Beardmore & Company, Limited, Dalmuir. Castings: F. H. Lloyd & Company, Limited, Wednesbury; Head, Wrightson & Company, Limited, Thornaby-on-Tees. High-speed drills: B.S.A. Tools, Limited, Birmingham; Samuel Osborn & Company, Limited, Sheffield; Thos. Firth & John Brown, Limited, Sheffield. Steel wire rope: R. Hood Haggie & Son, Limited, Newcastle-upon-Tyne; British Ropes, Limited, Dagenham; Latch & Batchelor, Limited, Birmingham; Dixon Corbitt, Limited, Gateshead-on-Tyne; Whitecross Company, Limited, Warrington; Binks Bros., Limited, London. *War Office.*—Bullet-proof plates: Vickers-Armstrongs, Limited, Sheffield. Steel rounds: Colvilles, Limited, Motherwell. Woven wire fencing: Darlington Fencing Company, Limited, Doncaster. *Crown Agents for the Colonies.*—Boiler tubes: Universal Steel Tube Company, Limited, Birmingham. Steel bars: P. & W. MacLellan, Limited, Glasgow. Steel tubes: Stewarts & Lloyds, Limited, Birmingham.

In view of the pressing need for immediate action, a temporary emergency tariff of a simple character should immediately be put into force, the Federation of British Industries urges. This tariff should be on an *ad valorem* basis graded into classes, the rates ranging from free entry for goods in the first class, by graded steps up to a maximum for goods placed in the last or highest class. In determining the commodities to be assigned to each class, the guiding principle should be generally that the nearer a commodity is to a completely finished article, the higher the rate of duty which it should bear when imported from a foreign country. This temporary tariff should be followed as speedily as possible by a more permanent tariff, calculated to meet more exactly the requirements of the industrial situation. Considerations which, it is stated, must be borne in mind, both in regard to the temporary and permanent tariff, include the necessity of considering the interests of industries which rely upon imported raw materials, or whose raw materials are themselves the finished products of other industries, the importance of reciprocal agreements for preferential treatment with the Dominions, and the need for elasticity in the tariff from the point of view of treaty negotiations with foreign countries.

## Obituary.

Mr. Alfred Henry Williams, a director of John Williams & Company (Wishaw), 1922, Limited, Wishaw, died suddenly, at the age of 73 years, whilst attending a meeting in Glasgow.

Mr. Matthew Paul, of Matthew Paul & Company, Limited, Dumbarton, died at his home in Kilcreggan, at the age of 72 years. He was well known in West of Scotland engineering circles.

Dr. Harry Phillips Davis, vice-president and director of the Westinghouse Electric & Manufacturing Company, chairman of the National Broadcasting Company and one of America's foremost engineers and executives, died on September 10.

Mr. Pearson Fisher, late technical engineer and adviser to Arrol-Johnston & Aster Engineering Company, Limited, died at Dumfries last month. Mr. Fisher served an apprenticeship with the Barrow Shipbuilding Company, and was employed for several years by the Dutch Government in the design and execution of engineering works. He was later works manager of Edward Chester & Company, Limited, Renfrew, and The Mirrlees Watson Company, Limited, Glasgow, and also served with William Denny & Bros., Limited, Dumbarton, and John Brown & Company, Limited.

## Personal.

Mr. G. L. Faulkner, B.Eng., has joined the staff of Ealing Park Foundry, Junction Road, South Ealing, London.

Mr. B. Trethewey, of Pegler Bros. & Company (Doncaster), Limited, brass founders, Belmont Works, Doncaster, received presentations from the directors and staff on the occasion of his marriage.

Owing to ill-health, Mr. J. Campbell has retired from active management in James Hall & Sons, Limited, Blue Boar Foundry, Rochester, Kent, but retains his seat on the board as consulting director. Mr. A. C. Fendick has joined the firm as managing director.

Sir Philip Cunliffe-Lister, M.P., has resigned the chairmanship of the Tin Producers' Association and of the council on his appointment as President of the Board of Trade. Sir George Maxwell has been unanimously appointed chairman until the next ordinary general meeting of members.

Mr. Arthur Skinner, works manager and a local director of Messrs. Hadfields, Limited, Sheffield, is retiring after 36 years' service with the firm. Mr. Skinner was the recipient of a presentation at a gathering in Sheffield recently. Mr. P. B. Brown, the Master Cutler, who is deputy-chairman of the company, presided, and the presentation was made by Mr. J. P. Crosbie, a director.

### Wills.

| | |
|---|---|
| Phinn, W. R., metal broker, of Dumfries | £17,724 |
| Turner, Henry E., ironfounder, Dorking ... ... ... ... ... ... | £9,357 |
| Stewart, J. C., of Belfast, engineer and brassfounder ... ... ... ... | £17,609 |

## New Companies.

**Premier Die Castings, Limited,** 219, West Ferry Road, E.—Capital £100. Directors: Mrs. B. Daniels and C. F. Swain.

**Charltons Engineering & Shipbuilding Company, Limited,** The Shipyard, Great Grimsby.—Capital £16,000 in £1 shares (10,000 6 per cent. cumulative preference). Directors: R. H. & G. H. Charlton and J. R. Kinnis.

**Textile Machinery Makers, Limited.**—Capital £100 in £1 shares, to acquire the land, buildings, machinery, manufacturing and ancillary undertakings and business of Asa Lees & Company, Limited, Brooks & Doxey (1920), Limited, Dobson & Barlow, Limited, Howard & Bullough, Limited, John Hetherington & Sons, Limited, and Platt Bros. & Company, Limited. Directors: Sir George Bullough, W. D. Smith, J. Redman, J. L. Rushton, H. L. Rushton, A. H. Lawton, E. V. Haigh, Sir Walter Preston, M.P., A. Brothers and A. W. Rippon.

## Company Meeting.

**Brightside Foundry & Engineering Company, Limited.**—At the annual meeting of the Brightside Foundry & Engineering Company, Limited, held in Sheffield recently, Mr. F. W. Firth (the chairman) said that the present small demand for steelworks and rolling-mill plant, particularly in this country, had caused them to look for other specialities, and they had acquired the manufacturing and selling rights of a patent machine for drying washed slack coal for pulverising purposes, and coke, etc. They had recently entered into an agreement with the patentee of a system for oil firing for central-heating plants.

## Reports and Dividends.

**North British Locomotive Company, Limited.**—Dividend on the preference shares of 2½ per cent. in respect of the half-year ended June 30, 1931.

**Neepsend Steel & Tool Corporation, Limited.**—Profit, £25,794; brought in, £3,199; final dividend of 6 per cent. on the ordinary shares and an additional 3 per cent. on the 6 per cent. preference, making 9 per cent. for the year on each class of share; to investments depreciation account, £7,500; carried forward, £5,328.

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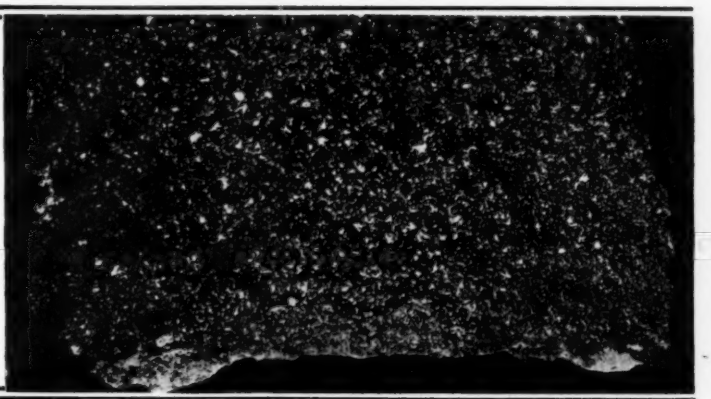

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# Raw Material Markets.

Consumers of pig-iron are still inclined to pursue a cautious policy. However, if there is any revival in the heavy industries, as is expected, they will soon be forced on the market, for their stocks have been at a low ebb for a long time. Some have already begun purchasing, in fear of a rise in the price of the raw material. Steelmakers report no increase in the home consumption, but it is recognised that, in present circumstances, a larger proportion of the work available will be given to the home industry, although the present atmosphere of economy is rather detrimental to the undertaking of any new developments.

## Pig-Iron.

**MIDDLESBROUGH.**—After the first uncertainty as to the effect of the new conditions, there has been a resumption of business on the Middlesbrough market, a good number of transactions being recorded. There is a marked improvement in the number of inquiries from abroad, British iron now being 25 per cent. cheaper in foreign countries than it was three weeks ago. It remains to be seen whether any increase in prices will be made, for considerable inroads into producers' stocks have already been reported, while it is known that consumers have been working with a small margin of raw material. Meanwhile, prices are unchanged. No. 1 Cleveland foundry iron is quoted at 61s. per ton, No. 3 Cleveland G.M.B. at 58s. 6d., No. 4 foundry at 57s. 6d., and No. 4 forge at 57s. per ton.

In the East Coast hematite market there has been a decided improvement in demand, and the price has been increased by 5s. 6d. per ton, the current quotation being 65s. Even at the new price, there has been no slackening in demand, and a further increase is already prophesied in some quarters. Of course, it must be remembered that there are at present only four hematite furnaces in blast in the Cleveland area, but it is significant that, even then, large reductions have been effected in makers' stocks, and the total turnover last week was greater than had been experienced for some time.

**LANCASHIRE.**—Better conditions seem to be in store for the Lancashire pig-iron market. It is thought that the depreciation of sterling will have a beneficial effect upon the Lancashire cotton industry, which will be to the ultimate advantage of the pig-iron producers. Again, those consumers who have been delaying purchases in the hope of a further fall in prices, and have been managing with very small stocks, are now faced with the possibility of a rise. Hence a spurt in buying may be expected in the immediate future. For delivery to users in the Manchester price zone, Staffordshire, Derbyshire and North-East Coast brands of No. 3 iron remain at 67s. per ton, with Northamptonshire foundry iron at 65s. 6d., Derbyshire forge at 62s., Scottish No. 3 at 86s. and West Coast hematite iron at about 80s. 6d. per ton.

**MIDLANDS.**—Buyers in the Midlands are still cautious, but a new spirit of optimism is present, in contrast to the despondency which marked the first half of September. The demand has quickened considerably, and last week's turnover showed a noticeable improvement. As the foundries have not, as yet, had any appreciable increase in orders, it is apparent that they are fearing an increase in pig-iron prices. The Central Pig-Iron Producers' Association has held its usual monthly meeting, but has decided to make no change in controlled prices. For delivery to Birmingham and Black Country stations, the makers still quote 62s. 6d. for Northants No. 3 and 66s. for Derbyshire, North Staffordshire and Lincolnshire No. 3.

**SCOTLAND.**—The changed economic conditions have so far had no marked effect upon the demand for pig-iron in Scotland. Consumers are at present inclined to await events, but the general position seems to indicate a possible rise in prices of raw material. Scottish No. 3 foundry remains at 69s. 6d. per ton f.o.t. furnaces. Middlesbrough No. 3 is at 57s. 6d. at Grangemouth.

## Coke.

Blast-furnace coke remains a slow market, with supplies plentiful. Foundry coke is also on offer in large quantities, but the forward position has shown some improvement. The tendency of prices is towards higher levels.

## Steel.

There has been more movement in the finished-steel market recently, although no great influx of orders. Inquiries from abroad have been increasing, while, owing to the unfavourable rate of exchange, fewer home contracts are being placed abroad. The demand for semis is still limited. Continental sellers withdrew entirely from the market upon the sudden depreciation of the £. More inquiries have been diverted to the British manufacturers, but the demand in general has shown no sign of any revival.

## Scrap.

It is hoped that the improved position of the heavy industries, resultant upon the relinquishing of the gold standard, will have a beneficial effect upon the scrap iron and steel markets, but, in the interim, business remains slack. On the Cleveland market, heavy cast iron meets with a small demand at 40s., while good machinery scrap remains at 42s. per ton. The Midland scrap market continues to suffer from over-abundant supplies, particularly of heavy steel scrap. Heavy machinery cast-iron scrap in cupola sizes is offered at 45s. to 47s. 6d., delivered, and light cast-iron scrap at 37s. 6d. Prices continue to be only nominal in the South Wales market, such is the paucity of business. In Scotland the market is still under the influence of the very poor consumption, which so far shows no signs of recovery, and the large stocks which continue to accumulate. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is easy at 45s., while ordinary cast iron has fallen to 39s. to 40s. per ton.

## Metals.

The past few days have witnessed a great deal of activity on the Metal Exchange, and last week's turnover was the largest for some time. There has been an all-round increase in the price of non-ferrous metals, but it must be remembered that these rises in price are not due to an increase of value, but are made on account of the depreciation of sterling. Apart from the abnormal activity on the Exchange caused by the dropping of the gold standard, there has been no alteration in the general conditions, and home consumption remains at a low level. It is hoped that the demand may increase now that Britain's industries are placed in a more favourable position on the world's markets. Prices on the markets this week have fluctuated considerably.

**Copper.**—The price of copper in England has fluctuated considerably with the fall of the pound sterling, but in other countries the price has remained steady, partly because Copper Exporters, Inc., have maintained their c.i.f. quotation at 7.50 cents per pound. Speculative American sellers forced the price down on one day last week, but the market proved too strong for them. The position in the U.S.A. is now much improved, the domestic demand being stronger, and export sales on the increase. Messrs. Henry Gardner & Company, Limited, in commenting on the market, say that "very little business has been transacted." Consumers here, of course, are unwilling to buy in dollars, and, with the course of the foreign exchange so erratic and uncertain, it has been impossible to fix a sterling parity.

Closing quotations :—

*Cash.*—Thursday, £33 5s. to £33 7s. 6d.; Friday, £35 10s. to £35 12s. 6d.; Monday, £33 17s. 6d. to £34; Tuesday, £33 15s. to £34; Wednesday, £33 7s. 6d. to £33 10s.

*Three Months.*—Thursday, £34 5s. to £34 7s. 6d.; Friday, £36 12s. 6d. to £36 15s.; Monday, £35 2s. 6d. to £35 5s.; Tuesday, £35 7s. 6d. to £35 10s.; Wednesday, £34 7s. 6d. to £34 10s.

**Tin.**—Quotations for tin have been very uncertain since the depreciation of the pound, and the New York market is really more indicative of the fundamental position of tin than the London metal market. On the former Exchange, tin fell last Friday to 23 cents per pound for spot, as compared with 24.625 cents a week ago. More business has been reported since the fall in price. An official statement has just been issued with regard to the International Tin Committee's meeting on the 22nd inst. It says that, in view of the misleading statements which have been made, it was thought necessary to reaffirm the unanimity of the Governments concerned to secure the fullest co-operation amongst themselves. In the meantime, stocks are still heavy, in spite of all restriction schemes, and only an improvement in general consumption can relieve them.

Official closing prices :—

*Cash.*—Thursday, £126 10s. to £126 15s.; Friday, £132 5s. to £132 10s.; Monday, £125 to £125 5s.; Tuesday, £122 10s. to £122 15s.; Wednesday, £122 17s. 6d. to £123.

*Three Months.*—Thursday, £130 7s. 6d. to £130 10s.; Friday, £136 10s. to £136 15s.; Monday, £129 10s. to £129 15s.; Tuesday, £126 10s. to £126 15s.; Wednesday, £126 15s. to £127.

**Spelter.**—There has been a slight improvement in the position of the galvanised sheet industry, with a resultant increase in the demand for spelter. Part of the recent spurt in buying may, however, be attributed to the fact that consumers are buying to replenish their limited stocks, and to secure themselves against a further rise in price. In the meantime, the market is chiefly influenced by the fluctuations of sterling.

Daily fluctuations :—

*Ordinary.*—Thursday, £13; Friday, £13 16s. 3d.; Monday, £12 17s. 6d.; Tuesday, £12 12s. 6d.; Wednesday, £12 17s. 6d.

**Lead.**—The position of this metal has shown a definite improvement, beyond the rise in price demanded by the depreciation of sterling, as there has been a greatly increased demand from home consumers, who are receiving an increased number of orders from abroad for finished goods. It is a favourable factor that the present buying is for consumption, and not for future speculation. The strong position of this metal is a satisfactory feature of the markets.

The week's prices have been :—

*Soft Foreign (Prompt).*—Thursday, £14 10s.; Friday, £15 10s.; Monday, £13 15s.; Tuesday, £14 8s. 9d.; Wednesday, £14 3s. 9d.

## Students' Corner.

(*Continued from page* 156.)

*Q.—Explain the procedure with a complicated weld.*

**A.—The process with a complicated weld, such as a long crack or rupture, if the weld is horizontally performed, would be as follows :—(1) Open out the crack by means of a cold chisel, preferably to a V-shaped groove ; (2) shape loam cakes for the underside of the weld conforming to the contour of the casting ; (3) the loam cakes should cover a margin of at least 2 in. on either side of the crack ; (4) the loam cakes on the underside require a backing of rammed floor sand for support, as these take the heat or impingement of the welding metal ; (5) after the loam cakes have been fitted into position, they are removed, and the casting is pre-heated, after which the loam cakes are replaced, and (6) strong sand or pieces of loam cake are placed on the top side of the casting, forming a canal in line with the large opening of the V-groove. These are banked higher than the level of the casting.**

**Run-offs may be arranged at one or both ends of the part being welded. The stream from the ladle containing the welding metal commences impinging, and is guided backwards and forwards the length of the weld until the metal on both sides of the V-groove is in a molten condition. Pouring now ceases, leaving the welded part a little higher than the surface of the casting, which is dressed off when cold.**

(*To be continued.*)

**Where the corrosion of gears** causes trouble, the addition of a small amount of zinc oxide to the lubricant will effect improvement.

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*Manchester:* F. L. HUNT & CO., Chapel Street, SALFORD, MANCHESTER.

# WEEKLY PRICE CURRENT.

## COPPER.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 33 | 7 | 6 |
| Three months | 34 | 7 | 6 |
| Electrolytic | 40 | 10 | 0 |
| Tough | 36 | 0 | 0 |
| Best selected | 36 | 10 | 0 |
| Sheets | 75 | 10 | 0 |
| India | 60 | 0 | 0 |
| Wire bars | 42 | 0 | 0 |
| Do., November | 42 | 0 | 0 |
| Do., December | 42 | 0 | 0 |
| Ingot bars | 42 | 0 | 0 |
| H.C. wire rods | 46 | 0 | 0 |
| Off. av. cash, August | 32 | 12 | 3 |
| Do., 3 mths., August | 33 | 10 | 0 |
| Do., Sttlmnt., August | 32 | 12 | 1½ |
| Do., Electro, August | 35 | 19 | 7½ |
| Do., B.S., August | 34 | 1 | 3 |
| Do., wire bars, August | 36 | 11 | 6 |
| Solid drawn tubes | | | 10¾d. |
| Brazed tubes | | | 10½d. |
| Wire | | | 7½d. |

## BRASS.

| | |
|---|---|
| Solid drawn tubes | 9¾d. |
| Brazed tubes | 11½d. |
| Rods, drawn | 8¾d. |
| Rods, extd. or rlld. | 5¾d. |
| Sheets to 10 w.g. | 8¼d. |
| Wire | 8½d. |
| Rolled metal | 7¾d. |
| Yellow metal rods | 5¼d. |
| Do. 4 × 4 Squares | 6d. |
| Do. 4 × 3 Sheets | 6d. |

## TIN.

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 122 | 17 | 6 |
| Three months | 126 | 15 | 0 |
| English | 124 | 10 | 0 |
| Bars | 126 | 5 | 0 |
| Straits | 126 | 0 | 0 |
| Australian | 124 | 10 | 0 |
| Eastern | 131 | 0 | 0 |
| Banca | 128 | 10 | 0 |
| Off. av. cash, August | 114 | 19 | 1½ |
| Do., 3 mths., August | 117 | 9 | 4½ |
| Do., Sttlmt., August | 114 | 19 | 0 |

## SPELTER.

| | £ | s. | d. |
|---|---|---|---|
| Ordinary | 12 | 17 | 6 |
| Remelted | 12 | 0 | 0 |
| Hard | 10 | 0 | 0 |
| Electro 99.9 | 14 | 17 | 6 |
| English | 13 | 5 | 0 |
| India | 12 | 0 | 0 |
| Zinc dust | 23 | 0 | 0 |
| Zinc ashes | 3 | 15 | 0 |
| Off. aver., August | 11 | 14 | 7¾ |
| Aver. spot, August | 11 | 8 | 9¾ |

## LEAD.

| | £ | s. | d. |
|---|---|---|---|
| Soft foreign ppt. | 14 | 3 | 9 |
| English | 15 | 10 | 0 |
| Off. average, August | 11 | 19 | 4½ |
| Average spot, August | 11 | 18 | 10½ |

## ZINC SHEETS, &c.

| | £ | s. | d. |
|---|---|---|---|
| Zinc sheets, English | 23 | 0 | 0 |
| Do., V.M. ex-whf. | 23 | 10 | 0 |
| Rods | 29 | 0 | 0 |
| Boiler plates | | | — |
| Battery plates | | | — |

## ANTIMONY.

| | £ | s. | d. |
|---|---|---|---|
| Special brand, Eng. | 40 | 0 | 0 |
| Chinese | 24 | 15 | 0 |
| Crude | 18 | 0 | 0 |

## QUICKSILVER.

Quicksilver (nom.) .. 20 16 6

## FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
25% .. 8 15 0 to 9 10 0
45/50% .. 10 5 0 to 12 10 0
75% .. 16 0 0 to 17 10 0
Ferro-vanadium—
35/50% .. 12/8 lb. Va.
Ferro-molybdenum—
70/75% c. free 4/2 lb. Mo. plus 20%
Ferro-titanium—
23/25% carbon-free 9½d. to 10½d. lb.
Ferro-phosphorus, 20/25% .. £16 0 0 to 17 10 0
Ferro-tungsten—
80/85% .. 1/8½ lb. plus 20%
Tungsten metal powder—
98/99% .. 1/11½ lb. plus 20%
Ferro-chrome—
2/4% car. (nom.) .. £33 10 0
4/6% car. (nom.) .. £25 10 0
6/8% car. (nom.) .. £24 10 0
8/10% car. (nom.) .. £23 0 0
Ferro-chrome—
Max. 2% car. (nom.) .. £35 0 0
Max. 1% car. (nom.) .. £39 0 0
Max. 0·70% car. (nom.) .. £41 0 0
70%, carbon-free (nom.) .. 11d. lb.
Nickel—99% .. £205 to £210 0 0
Ferro-cobalt .. 8/6 lb.
Aluminium 98/99% .. £95 0 0
Metallic chromium—
96/98% .. 3/1 lb.
Ferro-manganese (net)—
76/80% loose £10 15 0 to £11 5 0
76/80% packed £11 15 0 to £12 5 0
76/80% export (nom.) £ 9 0 0
Metallic manganese—
94/96% carbon-free .. 1/6 lb.
Per ton unless otherwise stated.

## HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten 2s. 0d.
Finished bars, 18% tungsten 2s. 9d.
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares, 3 in. and over .. 4d. lb.
Rounds and squares, under ½ in. to ¼ in. .. 3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in. .. 1/– lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¼ in. .. 3d. lb.
Do., under ½ in. × ¼ in. .. 1/– lb.
Bevels of approved sizes and sections .. 6d. lb.
Bars cut to length, 10% extra.

## SCRAP.

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| South Wales— | | | | | | | |
| Heavy steel | 1 | 17 | 6 | to | 1 | 19 | 0 |
| Bundled steel and shrngs. .. | 1 | 12 | 0 | to | 1 | 15 | 0 |
| Mixed iron and steel .. | 1 | 12 | 0 | to | 1 | 13 | 0 |
| Heavy cast iron .. | | | 2 | 0 | | | 0 |
| Good machinery for foundries | 2 | 2 | 6 | to | 2 | 5 | 0 |
| Cleveland— | | | | | | | |
| Heavy steel .. | | | 1 | 17 | | | 6 |
| Steel turnings .. | | | 1 | 5 | | | 0 |
| Cast-iron borings .. | | | 1 | 2 | | | 0 |
| Heavy forge .. | | | 2 | 7 | | | 6 |
| W.I. plating scrap .. | | | 2 | 0 | | | 0 |
| Cast-iron scrap | 2 | 0 | 0 | to | 2 | 2 | 0 |
| Midlands— | | | | | | | |
| Light cast-iron scrap .. | | | 1 | 17 | | | 6 |
| Heavy wrought .. | | | 2 | 0 | | | 0 |
| Steel turnings, f.o.r. .. | | | 0 | 14 | | | 6 |
| Scotland— | | | | | | | |
| Heavy steel .. | | | 1 | 15 | | | 0 |
| Ordinary cast iron .. | | | 1 | 19 | | | 0 |
| Engineers' turnings .. | | | 1 | 5 | | | 0 |
| Cast-iron borings .. | | | 1 | 10 | | | 0 |
| Wrought-iron piling .. | | | 2 | 2 | | | 6 |
| Heavy machinery .. | | | 2 | 5 | | | 0 |
| London—Merchants' buying prices delivered yard. | | | | | | | |
| Copper (clean) .. | | | 27 | 10 | | | 0 |
| Brass .. | | | 19 | 10 | | | 0 |
| Lead (less usual draft) .. | | | 11 | 10 | | | 0 |
| Tea lead .. | | | 8 | 10 | | | 0 |
| Zinc .. | | | 6 | 10 | | | 0 |
| New aluminium cuttings .. | | | 56 | 0 | | | 0 |
| Braziery copper .. | | | 25 | 10 | | | 0 |
| Gunmetal .. | | | 21 | 0 | | | 0 |
| Hollow pewter .. | | | 82 | 0 | | | 0 |
| Shaped black pewter .. | | | 59 | 0 | | | 0 |

## PIG-IRON.

*(f.o.t. unless otherwise stated.)*

| | |
|---|---|
| N.E. Coast— | |
| Foundry No. 1 | 61/– |
| Foundry No. 3 | 58/6 |
| Foundry No. 4 | 57/6 |
| Forge No. 4 | 57/– |
| Hematite No. 1 | 65/6 |
| Hematite M/Nos. | 65/– |
| N.W. Coast— | |
| Hem. M/Nos. d/d Glas. | 72/6 |
| ,, d/d Birm. | 84/6 |
| Malleable iron d/d Birm. | — |
| Midlands— | |
| Staffs common* | — |
| ,, No. 4 forge* | 61/– |
| ,, No. 3 fdry.* | 66/– |
| Shrops basic | — |
| ,, Cold blast, ord. | — |
| ,, ,, roll iron | — |
| Northants forge* | 57/6 |
| ,, fdry. No. 3* | 62/6 |
| ,, fdry. No. 1* | 65/6 |
| Derbyshire forge* | 61/– |
| ,, fdry. No. 3* | 66/– |
| ,, fdry. No. 1* | 69/– |
| ,, basic* | — |
| *d/d Black Country dist. | |
| Scotland— | |
| Foundry No. 1 | 72/– |
| ,, No. 3 | 69/6 |
| Hem. M/Nos. d/d | 68/6 |
| Sheffield (d/d district)— | |
| Derby forge | 58/6 |
| ,, fdry. No. 3 | 63/6 |
| Lincs forge | — |
| ,, fdry. No. 3 | 63/6 |
| E.C. hematite | 75/– |
| W.C. hematite | 81/6 |
| Lancashire (d/d eq. Man.)— | |
| Derby forge | 62/– |
| ,, fdry. No. 3 | 67/– |
| Staffs fdry. No. 3 | 67/– |
| Northants fdry. No. 3 | 65/6 |
| Cleveland fdry. No. 3 | 67/– |
| Dalzell, No. 3 (special) | 102/6 to 105/– |
| Glengarnock, No. 3 | 86/– |
| Clyde, No. 3 | 86/– |
| Monkland, No. 3 | 86/– |
| Summerlee, No. 3 | 86/– |
| Eglinton, No. 3 | 86/– |
| Gartsherrie, No. 3 | 86/– |
| Shotts, No. 3 | 86/– |

## FINISHED IRON AND STEEL.

*Usual District deliveries for iron; delivered consumers' station for steel.*

| | £ | s. | d. | | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| Iron— | | | | | | | |
| Bars (cr.) | 9 | 15 | 0 | to | 10 | 5 | 0 |
| Nut and bolt iron | 8 | 5 | 0 | to | 8 | 10 | 0 |
| Hoops | 10 | 10 | 0 | to | 12 | 0 | 0 |
| Marked bars (Staffs) f.o.t. | | | 12 | 0 | | | 0 |
| Gas strip | 10 | 10 | 0 | to | 12 | 0 | 0 |
| Bolts and nuts, ¾ in. × 4 in. | | | — | | | | |
| Steel— | | | | | | | |
| Plates, ship, etc. | 8 | 15 | 0 | to | 8 | 17 | 6 |
| Boiler plts. | 8 | 17 | 6 | to | 9 | 15 | 0 |
| Chequer plts. | | | 10 | 7 | | | 6 |
| Angles | | | 8 | 7 | | | 6 |
| Tees | | | 9 | 7 | | | 6 |
| Joists | | | 8 | 15 | | | 0 |
| Rounds and squares, 3 in. to 5½ in. | | | 9 | 7 | | | 6 |
| Rounds under 3 in. to ¾ in. (Untested) .. | 6 | 12 | 6 | & up. | | | |
| Flats—8 in. wide and over | 8 | 12 | 6 | | | | |
| ,, under 8 in. and over 5 in. | 8 | 17 | 6 | | | | |
| Rails, heavy | 8 | 5 | 0 | to | 8 | 10 | 0 |
| Fishplates | | | 12 | 0 | | | 0 |
| Hoops (Staffs) | | | 9 | 5 | | | 0 |
| Black sheets, 24g. | | | 8 | 5 | | | 0 |
| Galv. cor. shts. 24g. | 9 | 5 | 0 | to | 9 | 15 | 0 |
| Galv. flat sheets | 9 | 15 | 0 | to | 10 | 5 | 0 |
| Galv. fencing wire, 8g. plain | | | — | | | | |
| Billets, soft | 5 | 2 | 6 | to | 5 | 10 | 0 |
| Billets, hard | | | 6 | 12 | | | 6 |
| Sheet bars | 4 | 12 | 6 | to | 5 | 2 | 6 |
| Tin bars | | | 4 | 12 | | | 6 |

## PHOSPHOR BRONZE.

| | Per lb. basis. |
|---|---|
| Strip | 11¼d. |
| Sheet to 10 w.g. | 12½d. |
| Wire | 12⅝d. |
| Rods | 12½d. |
| Tubes | 1/7d. |
| Castings | 12½d. |

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

## NICKEL SILVER, &c.

| | Per lb. |
|---|---|
| Ingots for raising | 7d. to 1/1 |
| Rolled— | |
| To 9 in. wide | 1/1 to 1/7 |
| To 12 in. wide | 1/1½ to 1/7½ |
| To 15 in. wide | 1/1½ to 1/7½ |
| To 18 in. wide | 1/2 to 1/8 |
| To 21 in. wide | 1/2½ to 1/8½ |
| To 25 in. wide | 1/3 to 1/9 |
| Ingots for spoons and forks | 7d. to 1/3½ |
| Ingots rolled to spoon size | 10d. to 1/6½ |
| Wire round— | |
| 3/– to 10 g. | 1/4½ to 1/11½ |

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

## AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2 foundry, Phila. | 16.26 |
| No. 2 foundry, Valley | 17.00 |
| No. 2 foundry, Birm. | 12.00 |
| Basic | 17.26 |
| Bessemer | 18.76 |
| Malleable | 18.76 |
| Grey forge | 18.26 |
| Ferro-mang. 80% | 85.00 |
| O.-h. rails, h'y, at mill | 43.00 |
| Billets | 29.00 |
| Sheet bars | 29.00 |
| Wire rods | 35.00 |
| | Cents. |
| Iron bars, Phila. | 2.09 |
| Steel bars | 1.60 |
| Tank plates | 1.60 |
| Beams, etc. | 1.60 |
| Skelp, grooved steel | 1.60 |
| Skelp, sheared steel | 1.60 |
| Steel hoops | 1.80 |
| Sheets, black, No. 24 | 2.40 |
| Sheets, galv., No. 24 | 2.90 |
| Wire nails | 1.90 |
| Plain wire | 2.20 |
| Barbed wire, galv. | 2.55 |
| Tinplates, 100-lb. box | $5.00 |

## COKE (at ovens).

| | |
|---|---|
| Welsh foundry | 25/– |
| ,, furnace | 15/– |
| Durham and Northumberland— | |
| ,, foundry | 14/– to 15/– |
| ,, furnace | 13/6 |
| Midlands, foundry | — |
| ,, furnace | — |

## TINPLATES.

f.o.b. Bristol Channel ports.

| | | |
|---|---|---|
| I.C. cokes | 20×14 box (nom.) | 14/6 to 15/– |
| ,, | 28×20 ,, | — |
| ,, | 20×10 ,, | — |
| ,, | 18¾×14 ,, | — |
| C.W. | 20×14 ,, | — |
| ,, | 28×20 ,, | — |
| ,, | 20×10 ,, | — |
| ,, | 18¾×14 ,, | — |

## SWEDISH CHARCOAL IRON & STEEL.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pig-iron | £6 | 0 | 0 | to | £7 | 0 | 0 |
| Bars, hammered, basis | £16 | 10 | 0 | to | £17 | 0 | 0 |
| Bars and nail-rods, rolled, basis | £15 | 17 | 6 | to | £16 | 5 | 0 |
| Blooms | £10 | 0 | 0 | to | £12 | 0 | 0 |
| Keg steel | £32 | 0 | 0 | to | £33 | 0 | 0 |
| Faggot steel | £18 | 0 | 0 | to | £23 | 0 | 0 |
| Bars and rods dead soft, st'l | £10 | 0 | 0 | to | £12 | 0 | 0 |

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

### TUBES AND FITTINGS.

Current Discounts.

| | *Tubes.* | *Fittings.* |
|---|---|---|
| Gas .. .. | 62½% | 57½% |
| Water .. | 58½% | 52½% |
| Steam .. | 55% | 47½% |

W.I. 12½% extra.

### DAILY FLUCTUATIONS.

**Standard Copper** (cash).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 33 | 5 | 0 | inc. | 17/6 |
| .. | 25 | .. | 35 | 10 | 0 | ,, | 45/- |
| .. | 28 | .. | 33 | 17 | 6 | dec. | 32/6 |
| ,, | 29 | .. | 33 | 15 | 0 | ,, | 2/6 |
| ,, | 30 | .. | 33 | 7 | 6 | ,, | 7/6 |

**Electrolytic Copper.**

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 38 | 10 | 0 | inc. | 20/- |
| ,, | 25 | .. | 43 | 0 | 0 | ,, | 90/- |
| ,, | 28 | .. | 41 | 5 | 0 | dec. | 35/- |
| ,, | 29 | .. | 41 | 0 | 0 | ,, | 5/- |
| ,, | 30 | .. | 40 | 10 | 0 | ,, | 10/- |

**Standard Tin** (cash).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 126 | 10 | 0 | inc. | 132/6 |
| ,, | 25 | .. | 132 | 5 | 0 | ,, | 115/- |
| ,, | 28 | .. | 125 | 0 | 0 | dec. | 145/- |
| ,, | 29 | .. | 122 | 10 | 0 | ,, | 50/- |
| ,, | 30 | .. | 122 | 17 | 6 | inc. | 7/6 |

**Tin** (English ingots).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 128 | 5 | 0 | inc. | 135/- |
| ,, | 25 | .. | 134 | 0 | 0 | ,, | 115/- |
| ,, | 28 | .. | 126 | 10 | 0 | dec. | 150/- |
| ,, | 29 | .. | 124 | 5 | 0 | ,, | 45/- |
| ,, | 30 | .. | 124 | 10 | 0 | inc. | 5/- |

**Zinc Sheets** (English).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 22 | 0 | 0 | inc. | 40/- |
| ,, | 25 | .. | 22 | 0 | 0 | No | change |
| ,, | 28 | .. | 23 | 0 | 0 | inc. | 20/- |
| ,, | 29 | .. | 23 | 0 | 0 | No | change |
| ,, | 30 | .. | 23 | 0 | 0 | ,, | ,, |

**Spelter** (ordinary).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 13 | 0 | 0 | inc. | 7/6 |
| ,, | 25 | .. | 13 | 16 | 3 | ,, | 16/3 |
| ,, | 28 | .. | 12 | 17 | 6 | dec. | 18/9 |
| ,, | 29 | .. | 12 | 12 | 6 | ,, | 5/- |
| ,, | 30 | .. | 12 | 17 | 6 | inc. | 5/- |

**Lead** (English).

| | | | £ | s. | d. | | |
|---|---|---|---|---|---|---|---|
| Sept. | 24 | .. | 16 | 0 | 0 | inc. | 25/- |
| ,, | 25 | .. | 17 | 0 | 0 | ,, | 20/- |
| ,, | 28 | .. | 15 | 5 | 0 | dec. | 35/- |
| ,, | 29 | .. | 15 | 15 | 0 | inc. | 10/- |
| ,, | 30 | .. | 15 | 10 | 0 | dec. | 5/- |

### AVERAGE MONTHLY PRICES OF STEEL SHIP ANGLES (NORTH OF ENGLAND).

| Year. | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Yearly average. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| 1896 .. .. | 4 15 0 | 4 17 6 | 5 0 0 | 5 0 0 | 5 0 0 | 4 17 6 | 4 17 6 | 4 17 6 | 4 17 6 | 5 0 0 | 5 7 6 | 5 7 6 | 4 19 9½ |
| 1897 .. .. | 5 7 6 | 5 7 6 | 5 7 6 | 5 5 0 | 5 0 0 | 5 0 0 | 5 2 6 | 5 2 6 | 5 2 6 | 5 2 6 | 5 0 0 | 5 5 0 | 5 3 5½ |
| 1898 .. .. | 5 5 0 | 5 5 0 | 5 5 0 | 5 7 6 | 5 13 9 | 5 15 0 | 5 15 0 | 5 15 0 | 5 17 6 | 6 0 0 | 6 5 0 | 6 7 6 | 5 14 3 |
| 1899 .. .. | 6 10 0 | 6 12 6 | 6 15 0 | 6 15 0 | 6 17 6 | 6 17 6 | 7 0 0 | 7 0 0 | 7 5 0 | 7 5 0 | 7 12 6 | 7 15 0 | 7 0 5 |
| 1900 .. .. | 7 15 0 | 8 0 0 | 8 2 6 | 8 5 0 | 8 5 0 | 8 7 6 | 8 7 6 | 8 2 6 | 8 2 6 | 8 0 0 | 7 10 0 | 7 10 0 | 8 0 7½ |
| 1901 .. .. | 6 15 0 | 6 12 6 | 6 5 0 | 6 0 0 | 6 0 0 | 5 10 0 | 5 15 0 | 5 17 6 | 6 0 0 | 5 17 6 | 5 17 6 | 5 15 0 | 6 0 5 |
| 1902 .. .. | 5 12 6 | 5 10 0 | 5 10 0 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 7 6 | 5 11 8 |
| 1903 .. .. | 5 6 3 | 5 6 3 | 5 7 6 | 5 12 6 | 5 12 6 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 0 0 | 5 8 9 |
| 1904 .. .. | 5 0 0 | 4 17 6 | 5 2 6 | 5 5 0 | 5 5 0 | 5 5 0 | 5 5 0 | 5 5 0 | 5 0 0 | 5 0 0 | 5 0 0 | 5 5 0 | 5 2 6 |
| 1905 .. .. | 5 5 0 | 5 7 6 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 10 0 | 5 12 6 | 6 2 6 | 6 12 6 | 6 12 6 | 5 14 4½ |
| 1906 .. .. | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 6 12 6 | 7 2 6 | 6 13 4 |
| 1907 .. .. | 6 17 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 7 2 6 | 6 12 6 | 6 12 6 | 7 0 5 |
| 1908 .. .. | 6 2 6 | 6 2 6 | 6 2 6 | 5 17 6 | 5 17 6 | 5 17 6 | 5 17 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 16 3 |
| 1909 .. .. | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 12 6 | 5 7 6 | 5 7 6 | 5 7 6 | 5 7 6 | 5 7 6 | 5 7 6 | 5 7 6 | 5 9 7 |
| 1910 .. .. | 5 16 3 | 5 17 6 | 5 17 6 | 6 1 6 | 6 2 6 | 6 2 6 | 6 2 6 | 6 2 6 | 6 2 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 2 2½ |
| 1911 .. .. | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 7 6 | 6 9 0 | 6 7 8½ |
| 1912 .. .. | 6 16 3 | 6 17 6 | 6 17 6 | 7 5 0 | 7 7 6 | 7 7 6 | 7 7 6 | 7 12 6 | 7 12 6 | 7 12 6 | 7 14 6 | 7 17 6 | 7 7 4½ |
| 1913 .. .. | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 11 6 | 7 7 6 | 6 15 6 | 6 7 6 | 6 2 6 | 7 8 11½ |
| 1914 .. .. | 6 2 6 | 6 2 6 | 6 2 6 | 6 2 6 | 6 2 6 | 5 15 0 | 5 15 0 | 6 15 0 | 7 0 0 | 7 0 0 | 7 1 3 | 7 5 0 | 6 8 7½ |
| 1915 .. .. | 7 17 0 | 8 5 0 | 8 17 6 | 9 5 0 | 9 5 0 | 9 15 0 | 9 15 0 | 9 15 0 | 9 15 0 | 9 15 0 | 10 15 0 | 10 15 0 | 9 8 3½ |
| 1916 .. .. | 11 3 1½ | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 |
| 1917 .. .. | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 |
| 1918 .. .. | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6 | 11 2 6½ |
| 1919 .. .. | 11 2 6 | 13 12 6 | 13 12 6 | 13 12 6 | 17 2 6 | 17 1 3 | 17 0 0 | 17 15 0 | 17 15 0 | 17 15 0 | 17 17 6 | 18 5 0 | 16 1 9 |
| 1920 .. .. | 19 10 0 | 20 0 0 | 21 10 0 | 22 0 0 | 23 5 0 | 24 0 0 | 24 0 0 | 24 0 0 | 24 15 0 | 24 10 0 | 24 0 0 | 24 0 0 | 22 19 2 |
| 1921 .. .. | 22 10 0 | 20 12 6 | 19 0 0 | 17 10 0 | 17 10 0 | 16 6 0 | 14 10 0 | 14 3 4 | 13 10 0 | 11 15 0 | 10 0 0 | 9 12 6 | 15 11 7 |
| 1922 .. .. | 9 17 6 | 10 0 0 | 10 0 0 | 10 0 0 | 10 0 0 | 9 17 6 | 9 10 0 | 8 15 7½ | 8 14 0 | 8 12 6 | 8 12 6 | 8 12 6 | 9 7 8½ |
| 1923 .. .. | 8 18 1½ | 9 1 3 | 9 14 0 | 10 0 0 | 10 0 0 | 10 0 0 | 9 8 9 | 9 9 6 | 9 10 0 | 9 8 9 | 9 11 6 | 9 18 9 | 9 11 8½ |
| 1924 .. .. | 10 0 0 | 9 18 1½ | 9 17 6 | 9 17 6 | 9 17 2 | 9 11 3 | 9 15 0 | 9 15 0 | 9 9 4½ | 9 6 6 | 9 5 0 | 9 5 0 | 9 13 1½ |
| 1925 .. .. | 9 2 0 | 9 0 11½ | 9 0 0 | 8 15 9 | 8 10 3½ | 8 9 0½ | 8 6 3 | 8 2 6 | 7 19 0½ | 7 12 3 | 7 5 0 | 7 2 6 | 8 5 5½ |
| 1926 .. .. | 7 2 6 | 7 2 6 | 7 2 6 | 7 3 4 | 7 2 6 | 7 3 9 | 7 7 6 | 7 8 5½ | 7 9 0 | 7 12 6 | 7 16 3 | 8 0 6 | 7 7 7½ |
| 1927 .. .. | 7 18 9 | 7 17 6 | 7 17 6 | 7 14 8½ | 7 13 9 | 7 12 6 | 7 12 6 | 7 12 6 | 7 12 6 | 7 12 6 | 7 12 6 | 7 12 6 | 7 14 1½ |
| 1928 .. .. | 7 12 6 | 7 14 9 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 7 16 10½ |
| 1929 .. .. | 7 17 6 | 7 17 6 | 7 17 6 | 7 17 6 | 8 0 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 2 6 | 8 5 0 | 8 0 10½ |
| 1930 .. .. | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 |
| 1931 .. .. | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | 8 7 6 | — | — | — | — | — |


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